Planning Data
for the
Sweet Potato Industry

A. E. INFORMATION SERIES NO. 92
DEPARTMENT OF AGRICULTURAL ECONOMICS
NORTH CAROLINA STATE COLLEGE
RALEIGH, NORTH CAROLINA
JUNE 1962

Planning Data For The Sweet Potato Industry

33.492
1431P
v.1

633.49
M431P
v. 1-4

Planning Data For The Sweet Potato Industry

1. Prices, Production And Assembly Costs

Gene A. Mathia
Graduate Assistant

Richard A. King
M. G. Mann Professor

A. E. Information Series No. 92
Department of Agricultural Economics
North Carolina State College
Raleigh, North Carolina
June, 1962

TABLE OF CONTENTS

Page

SUMMARY.. 3
LIST OF TABLES... 4
LIST OF APPENDIX TABLES.. 4
LIST OF FIGURES.. 6
INTRODUCTION... 7
COMPARISON OF FRESH MARKET AND PROCESSING SALES................ 8
  Variables to be Considered................................... 8
  Production and Harvesting Costs.............................. 10
  Returns to Land and Management............................... 10
    Farm Level... 10
    Market Level... 15
  Effect of Prices and Yield on Choice of Outlet............... 17

PRODUCTION IN COMPETING AREAS.................................. 23
  United States.. 23
  Eleven Commercial States..................................... 23
  South Atlantic States.. 23
  North Carolina... 24
    Production... 24
    Size of Enterprise... 27
    Density of Production...................................... 27

MARKET OUTLETS AND PRICE TRENDS................................ 31
  Farm Disposition... 31
  Trends in Sweet Potato Prices, Value of Production and Sales. 32
  Possibilities for Expanding Demand........................... 34

CONCLUSIONS.. 39

APPENDIX... 41

* * * * * * * * * * * * * * * * *

PREFACE

This report is the first in a series on Planning Data for the Sweet Potato Industry to be published by the Department of Agricultural Economics, N. C. State College. It provides background data for firms in North Carolina currently engaged in or considering entering the sweet potato processing industry.

This series of studies contribute to the regional program of vegetable marketing research being conducted in the southern region under SM-8, Evaluation of Alternative Vegetable Marketing Organization and Handling Methods. Other agencies cooperating in this research are the agricultural experiment stations in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Puerto Rico, South Carolina, Tennessee, Texas and Virginia and the Marketing Economics Division of the United States Department of Agriculture.

SUMMARY

This report provides information regarding marketing alternatives for sweet potatoes and possibilities for expansion of the sweet potato industry in North Carolina. Opportunities for expanding plant capacity for processing sweet potatoes were of particular concern. A review of historical patterns of production, prices, disposition and value was made to supplement the comparison of marketing alternatives and to provide planning guides.

The two methods of marketing considered were (1) selling the total crop to processors and (2) selling to both fresh and processing markets according to size and grade of potato. Enterprise budgets were developed and price maps used to illustrate the prices necessary in the two markets to yield equal returns to land, operator's labor and management.

Production costs were estimated to be $121.45 per acre for growing expenses and $14.29 per acre for fixed expenses. These expenses were the same for each method of marketing. The difference in harvesting and grading between the two methods of marketing was about $.75 per hundredweight. Minimum yield for profitable sweet potato production was found to be 150 hundredweight per acre.

It was concluded that North Carolina sweet potato producers would be indifferent to the market selected if the average price in the combined market was $.75 per hundredweight greater than the price in the processing market, providing that both markets were located the same distance from the farm. Recent price levels have been such that continued sale of number one potatoes on the fresh market and other potatoes on the processed market appears profitable. New harvesting and handling methods may be developed which would shift farm costs so that sale of the entire crop to processors would be profitable.

LIST OF TABLES

Page

1. Variable and fixed expenses of growing marketable sweet potatoes yielding between 50 and 200 hundredweight per acre.......................................11

2. Harvesting and grading expenses for selected marketable yields of sweet potatoes..................12

3. Processing sales only: Total costs, total revenue and net returns to land, operator's labor and management at various prices and yields.............,13

4. Fresh and processing sales combined: Total costs, total revenue and returns to land, operator's labor and management at various average prices and yields..14

5. Replacement costs, annual fixed costs, variable costs and assembly labor costs for varying sizes of truck used in assembly operations.................16

6. Number of farms producing sweet potatoes and production, by size of enterprise, North Carolina, 1954 and 1959..28

7. Acres of sweet potatoes harvested and production on those farms harvesting 1 acre or more, by size of enterprise, North Carolina, 1954 and 1959.........29

LIST OF APPENDIX TABLES

1. Costs of transporting sweet potatoes from field to market, assuming varying lengths of haul and sizes of truck..41

2. Assembly costs of sweet potatoes with varying sizes of trucks, length of haul and yield..................42

3. Net returns to land, operator's labor, and management at varying plant prices, yields and length of haul with one and one-half ton truck; processing market only...43

4. Net returns to land, operator's labor and management at varying plant prices, yields, and length of haul with a two-ton truck; processing market only.........44

5. Net returns to land, operator's labor and management per acre at varying average prices, yields, and length of haul with a one and one-half ton truck; processing and fresh markets combined................45

LIST OF APPENDIX TABLES (continued)

Page

6. Net returns to land, operator's labor and management per acre at varying average prices, yields and length of haul with a two-ton truck; processing and fresh markets combined....46

7. Sweet potatoes: Acreage, yield, and production, United States, 1919-1961....47

8. Sweet potatoes: Acreage and production by state, 1949-58 average, 1959 and 1960....48

9. Sweet potatoes: Acreage, yield and production, North Carolina, 1941-50 average and 1950-1961....49

10. Production density in hundredweight per 100 acres of land area assuming different radii from a fixed point....50

11. Farm disposition of sweet potatoes, United States, 1919-1959....51

12. Sweet potato disposition, by state, 1959....52

13. Season average price received by farmers in dollars per hundredweight, by state, 1950-1959....53

14. Value of production of sweet potatoes, by state, 1950-1959....54

15. Value of sales of sweet potatoes, by state, 1950-1959....55

16. Quantity of sweet potatoes processed and per capita consumption of canned and fresh sweet potatoes, United States, 1940-1960....56

LIST OF FIGURES

Page

1. The relationship between average combined market price and processing price and returns to land, operator's labor and management per acre of green potatoes (100 hundredweight yield) 19

2. The relationship between average combined market price and processing price and returns to land, operator's labor and management per acre of green potatoes (150 hundredweight yield) 20

3. The relationship between average combined market price and processing price and returns to land, operator's labor and management per acre of green potatoes (200 hundredweight yield) 21

4. Acres of sweet potatoes grown for sale in North Carolina, 1958 25

5. Production of sweet potatoes in North Carolina, 1958, in thousand hundredweight 26

6. Average density of sweet potato production in North Carolina, 1958, in hundredweight per 100 acres of total area 30

7. Season average price per hundredweight received by farmers, 1919-1959 33

8. Per capita consumption of Irish and sweet potatoes, United States, 1940-58 35

9. Retail price indexes for all foods, fruits and vegetables, Irish potatoes and sweet potatoes, United States, 1939-1958 (1947-49 = 100) 37

10. Retail price and average farm price received by farmers for Irish and sweet potatoes, United States, 1944-58 38

Planning Data For The Sweet Potato Industry

1. Prices, Production And Assembly Costs

INTRODUCTION

The economic potential of commercial sweet potato production in North Carolina depends on efficiency in both production and marketing. Neither phase can be neglected without affecting the profitability of the sweet potato enterprise.

In general, the North Carolina sweet potato industry faces two main sources of competition. The first source comes from the factor side of production. Other alternative, more profitable enterprises may bid away factors of production. Mechanization of production of some enterprises has improved their relative position compared to sweet potatoes. Mechanization of sweet potato harvesting has not been as successful to date as in other enterprises.

The second source of competition comes from the market side including improvements in transportation and communication. Interregional competition has increased so that no area has a large locational advantage or control over an isolated market.

One indication that production efficiency has increased is the fact that yield per acre has been increasing in most areas. In North Carolina estimated yield per acre in 1961 was 110 hundredweight which is 39 hundredweight above the 10-year average. However, the portion of total production sold has not increased as rapidly as yield per acre. This might be one indication of the need for improvements in the marketing phase. Only about 68 percent of the total crop was sold off North Carolina farms in 1959. This ratio of off-farm sales to total production has remained about the same for several years. Other states market a much larger portion of their total production than does North Carolina.

Low sales per acre might be due to (1) the lack of profitable market outlets, either for raw or processed sweet potatoes and/or (2) the consumption rate for farm families in North Carolina is much greater than most other sweet potato producing states. The first explanation seems to be a partial answer especially with regard to the market for canner grade sweet potatoes which comprise about 20 percent of total production. There were only three processing plants in North Carolina in 1958. The fourth, a flaking plant, has been constructed and began operations in 1961. Small acreage of sweet potatoes per farm may also help explain the small proportion of the crop sold off North Carolina farms. Many farmers with small acreages produce sweet potatoes only for on-farm uses.

The establishment of better outlets for canner sweet potatoes in North Carolina may affect the industry in two important ways: (1) provide a market for off-size or off-grade sweet potatoes and (2) provide a market for more sweet potatoes, allowing farmers to increase production. If these two objectives are accomplished by establishing more processing plants, sweet potatoes could become increasingly important as a farm crop in North Carolina.

Processing plants require a large amount of capital for both initial investment and operating purposes. Planning for growth in the processing industry will require information concerning the potential supply of raw sweet potatoes and the demand for processed sweet potatoes. Information concerning the costs of operating a processing plant as well as expected future returns from its operation are presented in a companion study.1/ It shows clearly how variable costs and net returns are influenced by the level of output. Since the level of output depends on both demand and supply conditions, knowledge concerning the potential demand and supply for processed as well as for unprocessed sweet potatoes would be helpful.

The purpose of this report is to provide information which will describe the conditions necessary for expansion of sweet potato production in North Carolina. The approach to the problem is to compare the possible returns to land, operator's labor and management from two marketing alternatives. In addition to this analysis, historical patterns of production, acres harvested, disposition, value and prices are discussed. The report also contains a brief discussion of the possibilities for increasing sweet potato consumption.

COMPARISON OF FRESH MARKET AND PROCESSING SALES

Variables to be Considered

The profitability of sweet potato processing depends very largely on an adequate supply of the raw product. Factors

---

1/ Leigh H. Hammond, 1961. The Feasibility of Expansion in the Sweet Potato Canning Industry in Southern States. Forthcoming Marketing Research Report, USDA Marketing Economics Division in cooperation with the North Carolina Agricultural Experiment Station and the Louisiana Agricultural Experiment Station, Washington.

important in determining the supply of raw sweet potatoes are market conditions which establish relative prices, farm production costs which have considerable influence on the density of production, and assembly costs which are important in defining the supply areas for particular fresh and processing markets.

The two most common markets for sweet potatoes in North Carolina are the fresh (green or cured) market and the processing market. The fresh market furnishes an outlet for the better grades of sweet potatoes. The number one and jumbo grades can be sold on both fresh and processing markets. The canner grade of potatoes receives a near zero price in the fresh market. The processing market can utilize canners as effectively as the other two grades except for slightly higher trim and peel loss.

Returns to land, operator's labor and management were compared for two methods under various conditions. The first method is one in which the total quantity of marketable potatoes is sold to processors. The second method, which will be referred to as the combined method, involves sales in both the fresh and the processing markets. The number one and jumbo grades are sold on the fresh market and the canner grade of potatoes is sold to a processor.

Farm production costs vary depending on the market chosen. Potatoes can be produced at lower costs for processing than for the fresh market. The difference in cost is due mainly to the extra labor for grading and more expensive containers required for the fresh market.

Assembly costs do not necessarily vary with the method of marketing except where bulk handling is used for transporting potatoes for processing. These costs depend mainly on type of trucking facilities used and length of haul.

The effects of changes in yield, price, size of truck and distance traveled were studied. Yield was varied from 50 to 200 hundredweight per acre by 50 hundredweight intervals. Yield was considered to be dependent on such factors as the quality of land, type of growing and harvesting season, level of management and quality of labor. The grade distribution of yield was assumed to be 65 percent number one, 15 percent jumbo and 20 percent canner, based on experiments conducted at North Carolina State College.

Price was varied from $.50 to $2.50 per hundredweight for processing and $2.00 to $5.00 per hundredweight for the combined method of marketing. These average prices are based on the assumption that all marketable potatoes are sold.

Assembly costs were estimated for several sizes of truck and lengths of haul. The size of truck was varied from one-half to two tons. The quantity of potatoes hauled per load was based on the average licensed load limit in North Carolina for each size of truck. The distance from farm to market was varied from 5 to 30 miles round trip. Highway speed was assumed to be 20 miles per hour.

Production and Harvesting Costs

Variable growing expenses regardless of method selected were calculated to be $121.45 per acre (Table 1). Seed potatoes were the most important item of expense. Fixed expenses totaled $14.29 per acre. Note that transporting equipment was not included in fixed expenses at this point.

Harvesting and grading expenses vary with yield and with the method of marketing selected. These expenses for potatoes going to the processor would range from $23.90 per acre on a 50 hundredweight yield to $91.55 per acre on a 200 hundredweight yield (Table 2). For potatoes going to the combined markets these expenses would range from $60.61 per acre at 50 hundredweight to $238.39 per acre for yields of 200 hundredweight. Hired labor was the major item of expense for processing potatoes but the cost of containers was an equally important item of expense in the combined market.

Total costs for the combined market are somewhat higher for the same yield than for the processing market only. The difference in total production cost between the two methods of marketing is about $.75 per hundredweight. This results from the fact that containers are much more expensive and more labor is required for grading of potatoes going to the fresh market.

Returns to Land and Management

Farm Level. In the processing market, positive returns to land, operator's labor and management occur when yield is at least 100 hundredweight per acre (Table 3). The net farm price for processing potatoes must be at least $2.00 per hundredweight at this yield. Positive returns are possible at $1.50 per hundredweight but only at a yield of 200 hundredweight per acre.

When potatoes are sold in the combined market, a marketable yield of 50 hundredweight per acre produces positive returns to land, operator's labor and management at an average price of $4.00 per hundredweight (Table 4). In comparing the two methods at the same price, however, a 200 hundredweight yield per acre at $2.00 per hundredweight will return about $173.00 when sold to processors only while the same yield sold in the combined market will return about $26.00 per acre.

Table 1. Variable and fixed expenses of growing marketable sweet potatoes yielding between 50 and 200 hundredweight per acre[a]

Item	Description	Unit	Quantity	Price (dol.)	Amount (dol.)
Variable expenses					
Seed		cwt.[b]	7.5	6.00	45.00
Pre-sprouting seed		cwt.	7.5	.30[c]	2.25
Plant bed treatment	Puritized agricultural spray	pt.	1.0	1.00	1.00
Plant bed fumigant	Methyl bromide	lbs.	3.0	.85	2.55
Plant bed cover		sq. yd.	25.0	.10	2.50
Plant bed fertilizer	N	lbs.	1.6	.12	.19
	P	lbs.	1.6	.09	.14
	K	lbs.	1.6	.05	.08
	N	lbs.	90.0	.12	10.80
	P	lbs.	60.0	.09	5.40
	K	lbs.	160.0	.05	8.00
Soil fumigation	Row treatment[d]				13.00
Insecticides	Aldrin (2 lbs.)	gal.	1.0	4.00	4.00
Hired labor	Plant and cultivate	hr.	26.5	.75	19.88
Tractor	Medium (plant and cultivate)	hr.	14.8	.45	6.66
Total variable growing expenses					121.45
Fixed expenses[e]					
Tractor	Medium	hr.	17.8	.49	8.72
Other equipment	Plow, harrow, cultivator and miscellaneous tools				5.57
Total fixed expenses					14.29

[a] Yield is assumed to be dependent on such factors as quality of land, type of season, level of management and operator's labor rather than on variations in items listed above.

[b] Seed purchased every three years.

[c] Includes moving and heating.

[d] DD, EDB or Telone.

[e] Truck costs are included in the assembly operations.

Table 2. Harvesting and grading expenses for selected marketable yields of sweet potatoes

Item	Description	Unit	Price per unit	Yield of marketable potatoes (cwt.)							
				50		100		150		200	
				Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
			(dol.)		(dol.)		(dol.)		(dol.)		(dol.)
A. Processing market only[a]											
Containers[b]	Baskets	50 lb.	.38	10	3.80	20	7.60	30	11.40	40	15.20
Hired labor[c]		hr.	.75	25	18.75	50	37.50	75	56.25	100	75.00
Tractor	Medium (digging)	hr.	.45	3	1.35	3	1.35	3	1.35	3	1.35
Total					23.90		46.45		69.00		91.55
B. Fresh and processing markets[d]											
Containers	Baskets[b]	50 lb.	.38	2	.76	4	1.52	6	2.28	8	3.04
	Baskets	50 lb.	.45	80	36.00	160	72.00	240	108.00	320	144.00
Hired labor[e]		hr.	.75	30	22.50	60	45.00	90	67.50	120	90.00
Tractor	Medium (digging)	hr.	.45	3	1.35	3	1.35	3	1.35	3	1.35
Total					60.61		119.87		179.13		238.39

[a] Grading would not be done for potatoes going to a processing plant.

[b] Potatoes are transported in bulk, but baskets are used to pick up and load the truck. The quantity of baskets required was calculated on the basis of using the basket ten times. Lids are not included in the price of baskets used in picking up canners.

[c] Assumes .5 hour per hundredweight.

[d] Grading is required and the distribution of grades is assumed to be: 65 percent No. 1, 20 percent canners and 15 percent jumbos.

[e] Assumes .6 hour per hundredweight due to additional grading required.

Table 3. Processing sales only: Total costs, total revenue and net returns to land, operator's labor and management at various prices and yields

Item	Yield[a] of marketable potatoes (cwt.)			
	50	100	150	200
	(dollars per acre)			
Total costs				
Growing	121.45	121.45	121.45	121.45
Harvesting and sacking	23.90	46.45	69.00	91.55
Fixed expenses	14.29	14.29	14.29	14.29
Total costs	159.64	182.19	204.74	227.29
Total revenue				
Average farm price[b]				
$ .50/cwt.	25.00	50.00	75.00	100.00
1.00/cwt.	50.00	100.00	150.00	200.00
1.50/cwt.	75.00	150.00	225.00	300.00
2.00/cwt.	100.00	200.00	300.00	400.00
2.50/cwt.	125.00	250.00	375.00	500.00
Returns to land, operator's labor and management				
Average farm price[b]				
$ .50/cwt.	-134.64	-132.19	-129.74	-127.29
1.00/cwt.	-109.64	- 82.19	- 54.74	- 27.29
1.50/cwt.	- 84.64	- 32.19	20.26	72.71
2.00/cwt.	- 59.64	17.81	95.26	172.71
2.50/cwt.	- 34.64	67.81	170.26	272.71

[a] 65 percent, No. 1; 20 percent, canners; 15 percent, jumbo.

[b] Net prices at farm, representing f.o.b. plant price less hauling costs.

Table 4. Fresh and processing sales combined: Total costs, total revenue and returns to land, operator's labor and management at various average prices and yields

Item	Yield of marketable potatoes (cwt.)			
	50	100	150	200
		(dollars per acre)		
Total costs				
Growing costs	121.45	121.45	121.45	121.45
Harvesting, grading and packaging	60.61	119.87	179.13	238.39
Fixed costs	14.29	14.29	14.29	14.29
Total costs	196.35	255.61	314.87	374.13
Total revenue				
Average farm prices[b]				
$2.00/cwt.[c]	100.00	200.00	300.00	400.00
3.00/cwt.	150.00	300.00	450.00	600.00
4.00/cwt.	200.00	400.00	600.00	800.00
5.00/cwt.	250.00	500.00	750.00	1,000.00
Returns to land, operator's labor and management				
Average farm prices[b]				
$2.00/cwt.[c]	- 96.35	- 55.61	- 14.87	25.87
3.00/cwt.	- 46.35	44.39	135.13	225.87
4.00/cwt.	3.65	144.39	285.13	425.87
5.00/cwt.	53.65	244.39	435.13	625.87

---

[a] 65 percent, No. 1; 20 percent, canners; 15 percent, jumbo.

[b] Net prices at farm, representing f.o.b. plant price less hauling costs.

[c] With No. 1 potatoes selling at $2.75, canners at $0.50 and jumbos at $0.75, the average price is $2.00/cwt. under the assumed grade distribution.

Market Level. Returns to land, operator's labor and management are further reduced by the amount of assembly costs. Assembly costs were computed for four different sizes of truck (Table 5). For example, the costs of operating a two-ton truck were estimated to be $320 per year for fixed truck expenses, $.076 per mile for variable truck expenses, $5.14 per load for loading and unloading labor and $.068 per mile for labor in transit. The length of haul was also varied. The total cost of operating a two-ton truck 5 miles was estimated to be $6.02 (Appendix Table 1). When a 50 hundredweight yield is hauled by a two-ton truck 5 miles, the total cost was estimated to be $5.79 (Appendix Table 2).

A linear transformation of this data to average costs per hundredweight resulted in the following assembly cost functions:

$$\hat{Y}_{1/2} = .084 + .0092X$$

$$\hat{Y}_{1} = .092 + .0056X$$

$$\hat{Y}_{1\ 1/2} = .095 + .0042X$$

$$\hat{Y}_{2} = .098 + .0034X$$

The $\hat{Y}$'s represent estimates of average cost per hundredweight for X distance. The subscript indicates the size of truck. The X's represent the distance traveled in miles per round trip from farm to market.

The difference in magnitude of the coefficients reflects the relative efficiency of larger trucks when the length of haul increases. For a one mile round trip, a one-half ton truck could deliver a hundredweight for about 9 cents while a two-ton truck could deliver the same hundredweight for about 10 cents. However, a longer round trip such as 30 miles will point out the advantage of the larger size truck. The cost per hundredweight for 30 miles is about 36 cents for the one-half ton truck but only 20 cents for the two-ton truck.

The effects of assembly costs on returns to land, operator's labor and management were determined by considering different yield and price combinations (Appendix Tables 3-6). The differences in returns to land, operator's labor and management of Tables 3 and 4 and Appendix Tables 3-6 represent assembly costs for each size of truck and length of haul.

The size of truck had little effect on assembly costs. For example, the net returns to land, operator's labor and management at a yield of 200 hundredweight and a price of $2.00 in the processing market were $136.91 at a distance of 10 miles one way from market when a one and one-half ton truck was used (Appendix Table 3). For a two-ton truck, the

Table 5. Replacement costs, annual fixed costs, variable costs and assembly labor costs for varying sizes of truck used in assembly operations

Item	Size of truck[a]			
	1/2 ton	1-ton	1 1/2-ton	2-ton
	(dollars per year)			
Fixed truck cost				
Depreciation[b]	100	115	120	140
Interest on investment[c]	32	34	37	45
Repairs[d]	10	11	13	15
Insurance[e]	86	87	95	102
Taxes, license fees and misc.[f]	12	13	15	18
Total annual costs	240	260	280	320
Variable truck cost	(dollars per mile)			
Gasoline (30 cents per gallon, 8, 7, 6.5, 6 miles/gallon, respectively)	.038	.043	.046	.050
Oil, grease, filters, etc.	.008	.009	.010	.011
Tires and tubes (20,000 miles)	.006	.007	.008	.010
Repairs (points, plugs, etc.)	.004	.004	.005	.005
Total variable cost per mile	.056	.063	.069	.076
Labor costs	(dollars per load)			
Loading and unloading[g]	1.28	2.57	3.86	5.14
	(dollars per mile)			
Transit[h]	.068	.068	.068	.068

[a] Truck specifications: 1/2-ton - 122" wheel base, truck weight approximately 3,000 pounds; 1-ton - 132" wheel base, truck weight approximately 3,500 pounds; 1 1/2-ton - 156" wheel base, truck weight approximately 4,500 pounds; 2-ton - 156" wheel base, truck weight approximately 4,900 pounds.

[b] Depreciation is calculated on basis of 10-year life, allocating 50 percent of truck use to the sweet potato enterprise.

[c] Interest computed at approximately 3 percent of replacement cost allocated to the sweet potato enterprise.

[d] Repairs computed at approximately 1 percent of replacement costs allocated to sweet potatoes.

[e] Insurance calculated on basis of $50 deductible collision and 10-20-5 liability with medical benefits.

[f] Taxes, licenses and miscellaneous items were estimated to be approximately 1 percent of replacement costs allocated to the sweet potato enterprise.

[g] Loading labor costs were calculated on the basis of a truck driver paid at a $1.35 per hour and 2 loaders paid at $1.25 per hour. Labor requirements for loading were the following: 1/2-ton (16 cwt.) = 30-man minutes; 1-ton (28 cwt.) = 60-man minutes; 1 1/2-ton (40 cwt.) = 90-man minutes; and 2-ton (52 cwt.) = 120-man minutes. Labor requirements for waiting and unloading performed by the truck driver were the following: 1/2-ton = 28-man minutes; 1-ton = 57-man minutes; 1 1/2-ton = 86-man minutes; and 2-ton = 115-man minutes.

[h] Labor in transit assuming only a truck driver was calculated on basis of 20 miles per hour speed.

net returns were $139.39 per acre under these same conditions (Appendix Table 4). The two-ton truck resulted in a net gain of $2.48 per acre or about one cent per hundredweight as compared with the smaller truck.

Effect of Prices and Yield on Choice of Outlet

The relationship between processing market price and combined market price for green potatoes and net returns can be demonstrated by price maps. This technique provides information which a producer can use in selecting the most profitable method of marketing when yield, size of truck, hauling distance and prices in the combined and processing markets are known.

Suppose a producer is located ten miles (one way) from the market and a two-ton truck is to be used. With yield and price estimates, the most profitable marketing alternative can be selected on the basis of the greatest returns to land, operator's labor and management from the two market alternatives. A yield of 100 hundredweight and a processing price of $1.99 or a combined market price of $2.73 per hundredweight would be required to yield a zero return to land, operator's labor and management (Figure 1). The iso-return line in Figure 1 indicates the prices in the two markets which will yield equal returns to the fixed factors. A return of $100 per acre would require about $3.00 in the processing market or about $3.75 per hundredweight in the combined markets.

Any combination of prices falling to the right of the iso-return line indicates that the combined market is the most profitable, and any combination of prices to the left of the iso-return line indicates that the processing market is the most profitable. For example, if the average combined price were $4.00 per hundredweight, the processing price would have to be greater than $3.25 per hundredweight before it would be profitable to sell the entire crop of potatoes to the processing market. The canner grade of potatoes would be sold to the processor as long as the processing price was greater than the additional cost of production and sale of these potatoes.

This analysis is useful to marketing frims as well as to producers. The iso-return line provides some indication of the price which must be offered to producers by one market to bid away the better grades of potatoes from the other market. For instance, a processor should not expect to purchase a very large quantity of number one green potatoes at a price less than $1.60 per hundredweight or better and growers can produce 150 hundredweight per acre (Figure 2).

A processor might point out that these estimates are biased in that the estimates are based on the assumption that the entire crop is sold under both marketing alternatives. It is true that approximately 20 percent of the total yield would not necessarily be sold if a processing market did not exist. However, the canner grade might be sold as livestock feed. These estimates of returns assume that canner potatoes could be sold at one-fourth of the average farm price when number one and jumbo potatoes are sold on the fresh market. If a market for canners is not available, the average price of number one and jumbo must be increased to offset the loss of revenue from the canner grade. The change in average price necessary to give the same net return depends on yield, price, size of truck and length of haul. The value of canners for livestock feed also must be considered.

Variations in the yield of potatoes, under the assumptions concerning costs and revenues, affect returns in two ways. The first is that the price combinations which result in negative returns to land, operator's labor and management decrease as yield increases, as shown by the shaded area of Figure 2. For example, when yield is 150 hundredweight per acre, zero returns to land, operator's labor and management occur at a processing price of about $1.53 per hundredweight or a combined market price of $2.27 per hundredweight (Figure 2). With a 200 hundredweight yield, zero returns occur when the processing price falls to about $1.30 or when the combined market price is about $2.05 per hundredweight (Figure 3).

The second change follows from the first in that the size of price changes required to increase returns to land, operator's labor and management by a given amount decreases as the yield is increased. This change in prices is reflected in the change in the distance between points along the iso-return lines as yield increases.

The change in the size of truck used or a change in the distance hauled affects the distance between given levels of net returns as well as the area of negative returns to land, operator's labor and management per acre. The level of prices in both markets would have to increase when smaller trucks or longer lengths of haul were considered if given net returns to land, operator's labor and management were maintained.

This analysis points out the fact that processors must be very much concerned with the source of the raw product. A recent study by Hammond pointed out that processing plants must be larger than is commonly believed, operated for longer lengths of season than existing plants in North Carolina are now operating, be able to operate the plant at about 100 percent capacity, and attain a low trim and peel loss if survival is to be accomplished.1/ In order to satisfy these conditions, a dependable source of raw potatoes is necessary.

1/ Leigh H. Hammond, 1961, The Feasibility of Expansion in the Sweet Potato Canning Industry in Southern States. Forthcoming Marketing Research Report, USDA Marketing Economics Division in cooperation with the North Carolina Agricultural Experiment Station and the Louisiana Agricultural Experiment Station, Washington.

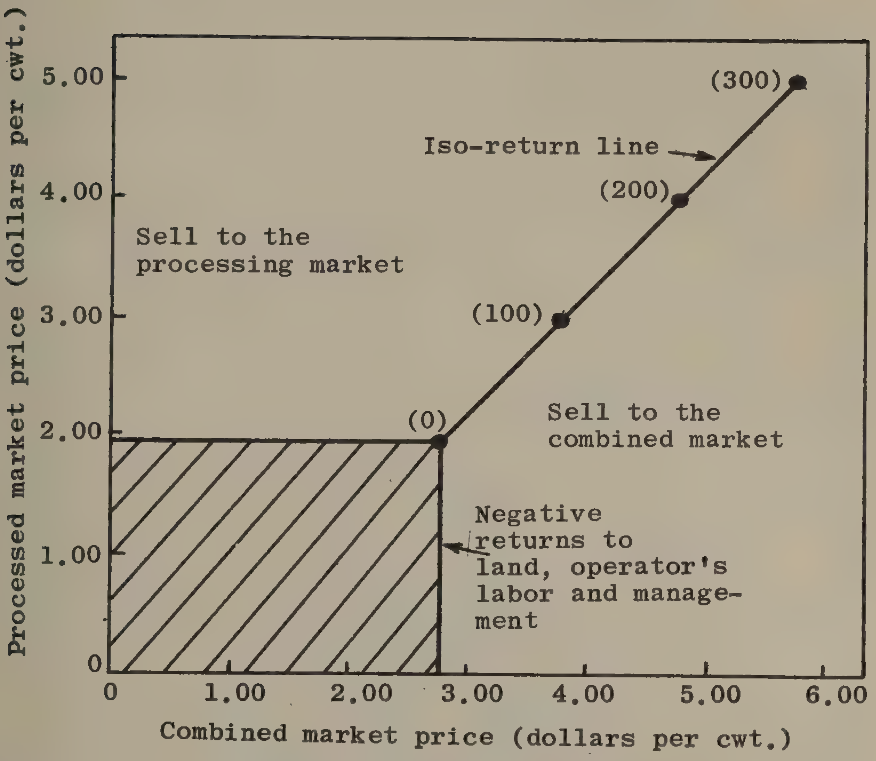


Figure 1. The relationship between average combined market price and processing price and returns to land, operator's labor and management per acre of green potatoes (100 hundredweight yield)[a]

[a] These estimates are calculated on the basis of a two-ton truck, a 10-mile, one way distance from the farm to the market and a 100 hundredweight yield. Returns to land, operator's labor and management per acre appear in parentheses along the iso-return line.

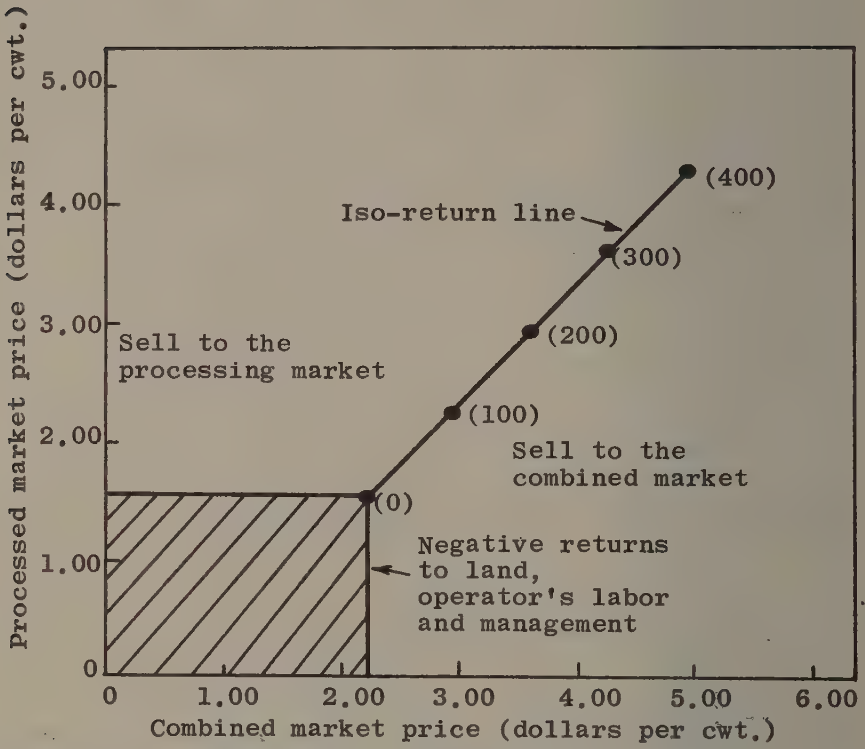


Figure 2. The relationship between average combined market price and processing price and returns to land, operator's labor and management per acre of green potatoes (150 hundredweight yield)[a]

---

[a] These estimates are calculated on the basis of a two-ton truck, a 10-mile haul (one way), and a 150 hundredweight yield. Returns to land, operator's labor and management per acre appear in parentheses along the iso-return line.

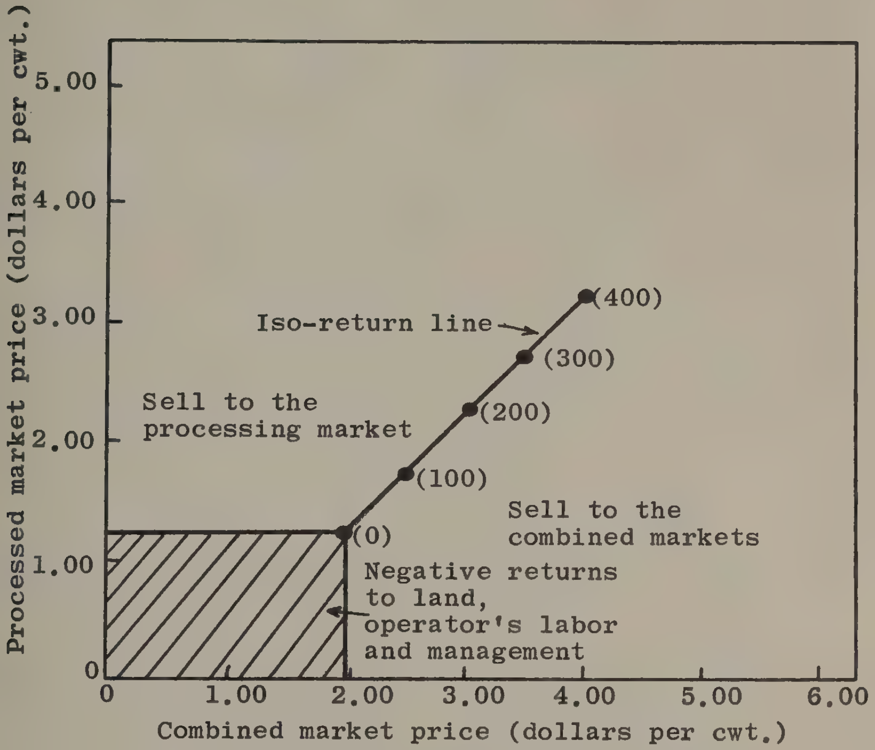


Figure 3. The relationship between average combined market price and processing price and returns to land, operator's labor and management per acre of green potatoes (200 hundredweight yield)[a]

---

[a] These estimates are calculated on the basis of a two-ton truck, a 10-mile haul (one way), and a 200 hundredweight yield. Returns to land, operator's labor and management per acre appear in parentheses along the iso-return line.

A look at past production and prices in both fresh and processing markets indicates that processors may anticipate trouble with the supply of green potatoes. For one thing, the supply of canner grade potatoes is not sufficient now to support a large processing industry. For instance, a 40 thousand pound per hour plant operating at 100 percent capacity would require 640,000 hundredweight of green potatoes per season to operate 1,600 hours. The preliminary estimate of total production of sweet potatoes in North Carolina in 1961 is 2,420,000 hundredweight. If the canner grade of potatoes represents 20 percent of total production, approximately 484,000 hundredweight of canner potatoes would be available. This quantity would be about 156,000 hundredweight less than the quantity required to operate this one plant at designed capacity. Thus, another source of green potatoes is required or the plant size must be reduced. Both alternatives will likely increase the average cost per case of processed sweet potatoes.

To develop new sources processors must either go outside North Carolina for their raw product or bid the better grades of potatoes away from the fresh market. Competition from processors for the better grades of potatoes in North Carolina has not been very great in the past. A commonly quoted price for green potatoes to process is $2.00 per hundredweight. This price does not compare favorably with recent prices quoted for marketable green potatoes in the fresh market. For example, the four major auction markets of Benson, Bethel, Faison, and Tabor City reported an average price of $3.84 per hundredweight during October and November of 1959.

Processors must increase their paying price of green potatoes if they are to compete with the fresh market for the better grades. The magnitude of the increase depends on the conditions of marketing. The increase necessary to bid potatoes away from the fresh market would not likely be the full difference of $1.84, but might be equal to or greater than $.73 depending on the location of the two markets. Such comparisons are possible by using the three preceding diagrams for various levels of yield and allowing for the difference in the length of haul to both markets.

There is no assurance that processors would be supplied with a sufficient quantity of potatoes to operate efficiently even though a competitive price could be offered. In fact, the fresh market price may have to be increased in order to get the quantity needed to supply the fresh market demand. A general observation of past trends indicates that total production has been declining while the price of green potatoes has been increasing. It might be advantageous at this point to look at the present situation and past trends in production patterns, disposition and prices in North Carolina and other important sweet potato producing areas.

PRODUCTION IN COMPETING AREAS

United States

Acreage of sweet potatoes harvested in the United States has decreased from 791,000 acres in 1919 to 203,000 acres harvested in 1960 (Appendix Table 7). This represents a decrease in acres harvested of about 74 percent from 1919 and about 81 percent decrease since the 1932 peak.

Total production of sweet potatoes in the United States has declined after reaching a peak of 47,627,000 hundredweight in 1932 to 15,636,000 hundredweight in 1960. The 1960 total production represents a 64 percent decrease from 1919 and a 67 percent decrease from the peak 1932 total production.

Even though acres harvested and total production have decreased since 1919, the yield per harvested acre has increased from 54.4 hundredweight in 1919 to 77.1 hundredweight in 1960. This represents a 42 percent increase in yield since 1919. It reached its low of 42.4 hundredweight in 1942. The yield in 1960 is an improvement of 82 percent since 1942.

Eleven Commercial States

There are approximately 22 states which produce sweet potatoes commercially. However, only 10 states harvested over 10,000 acres in 1959 (Appendix Table 8). These states also averaged more than 10,000 acres annually during the 10-year period, 1949-58. They were: Louisiana, North Carolina, Texas, South Carolina, Georgia, Mississippi, Alabama, Virginia, New Jersey and California. These 10 states accounted for about 89 percent of the total harvested acres in the United States in 1959.

Total production of sweet potatoes on a commercial basis followed the same general pattern as did the acreage harvested. The 10 leading states in order of production in 1959 were: Louisiana, North Carolina, Virginia, Texas, Mississippi, New Jersey, Georgia, California, South Carolina and Alabama. These 10 states accounted for 16,437,000 hundredweight or 87 percent of the United States production of 18,865,000 hundredweight in 1959.

South Atlantic States

Total acreage harvested in the South Atlantic states ranged between 4,000 and 42,500 acres, about 33 percent of the United States' average annual acreage during the 10-year period, 1949-58. North Carolina ranked second among all states in 1959 and first among the South Atlantic states with 31,000 acres harvested. This represented a considerable decrease compared with the 1949-58 average annual acreage harvested. The 10-year annual average was 42,500 compared to the 1959 quantity of 31,000 acres, a decrease of about 27 percent.

Total production in the South Atlantic states ranged from 171,000 hundredweight in Florida to 2,626,000 hundredweight in North Carolina for an average annual production of 6,557,000 hundredweight, about 34 percent of the United States' average annual production during the 10-year period. North Carolina produced 2,480,000 hundredweight in 1959. This represents a decrease of less than 6 percent from the 10-year average. The production changed much less in 1959 compared to the 1949-58 average than did the acres harvested. This was due to the remarkable increase in yield per acre. The yield per acre over the 10-year period averaged 72.3 hundredweight compared to 110 hundredweight in 1961 (Appendix Table 9). This represents a 52 percent increase.

North Carolina

Production. Three regions produce a very large proportion of North Carolina's production (Figure 4). These three regions were the Central Coastal with 8,375 acres, the Southern Coastal with 6,498 acres, and the Northern Coastal with 3,829 acres. Central Piedmont was the fourth largest producing region in acres of sweet potatoes with 1,297. These four regions in North Carolina produced nearly 91 percent of the 21,916 acres of sweet potatoes grown for sale in 1958.

There were eleven counties in 1958 that produced more than 500 acres of sweet potatoes for sale. These counties in order of acreage were: Johnston, Columbus, Sampson, Martin, Pitt, Beaufort, Harnett, Pamlico, Wayne, Duplin and Brunswick. These eleven counties produced about 60 percent of the total acres produced for sale. It would be expected that these counties would also supply the major share of the sweet potatoes for processing.

In total production of sweet potatoes in 1958, the three leading areas were the Central Coastal with 772,680 hundredweight, the Southern Coastal with 651,920 hundredweight, and the Northern Coastal with 437,340 hundredweight (Figure 5). These three districts produced 1,861,990 hundredweight or about 80 percent of the state's total production of 2,325,000 hundredweight in 1958.

Generally, the leading counties in terms of acres of sweet potatoes for sale also produced the largest quantity of sweet potatoes in 1958. Johnston which produced 348,000 hundredweight was by far the largest producing county. Following Johnston County in order of sweet potato production were: Columbus, Sampson, Martin, Pitt, Pamlico, Robeson,

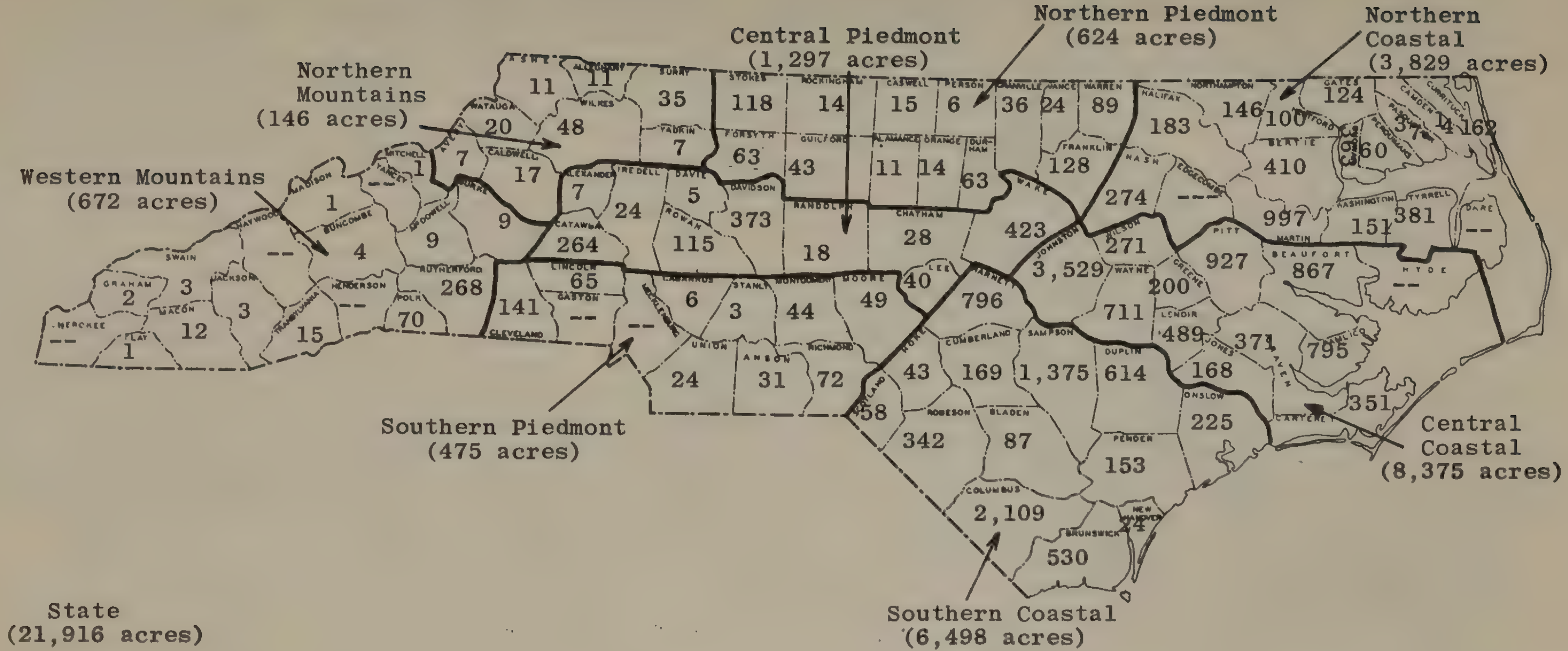

Northern Mountains (146 acres)
Western Mountains (672 acres)
Central Piedmont (1,297 acres)
Northern Piedmont (624 acres)
Northern Coastal (3,829 acres)
Southern Piedmont (475 acres)
Central Coastal (8,375 acres)
Southern Coastal (6,498 acres)
State (21,916 acres)

Figure 4. Acres of sweet potatoes grown for sale in North Carolina, 1958

Source: North Carolina Crop Reporting Service, Raleigh.

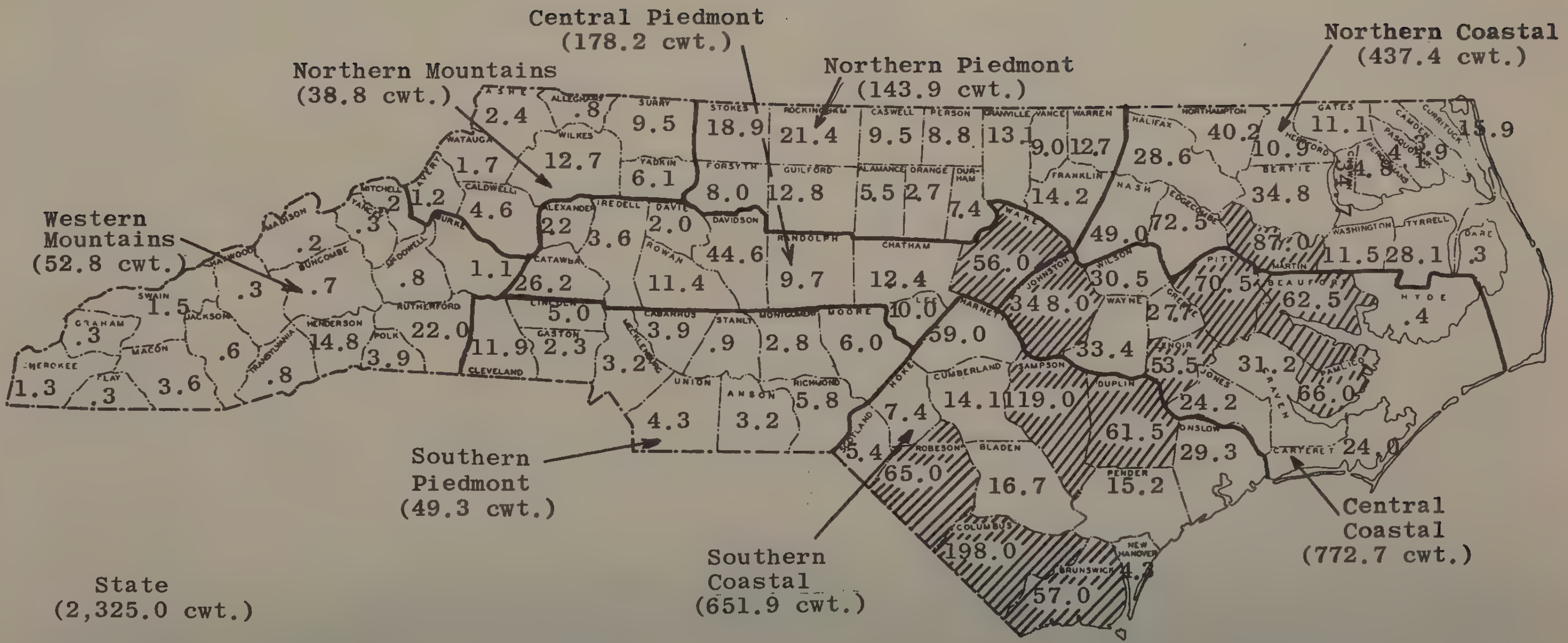

Central Piedmont (178.2 cwt.)
Northern Piedmont (143.9 cwt.)
Northern Coastal (437.4 cwt.)
Northern Mountains (38.8 cwt.)
Western Mountains (52.8 cwt.)
Southern Piedmont (49.3 cwt.)
Southern Coastal (651.9 cwt.)
Central Coastal (772.7 cwt.)
State (2,325.0 cwt.)

Figure 5. Production of sweet potatoes in North Carolina, 1958, in thousand hundredweight

Source: North Carolina Crop Reporting Service, Raleigh.

Beaufort, Duplin, Harnett, Brunswick, Wake and Lenoir. These thirteen counties were the only counties that produced more than 50,000 hundredweight in 1958. The production in these thirteen counties represented about 56 percent of the state's total production.

Size of Enterprise. The quantity of sweet potatoes harvested per farm may provide a further insight into the pattern of production in North Carolina. It may also provide an explanation for the relatively small proportion of sweet potatoes sold. In 1954, there were more than 93 thousand farms in North Carolina that reported a harvest of 3.6 million bushels of sweet potatoes (Table 6). In 1959, there were 47 thousand sweet potato producing farms reporting 3.8 million bushels. Average production increased from 39 to 82 bushels per farm. About 12 percent of these produced more than one acre in 1954 and 15 percent in 1959. Only 2,160 farms or less than 5 percent produced three acres or more in 1959.

About 19 percent of the total production in 1959 was from farms producing less than 1.0 acre of sweet potatoes. Most of these potatoes were probably grown for household consumption and would not normally enter merket channels. Complete data on acreage harvested are available only for farms harvesting one or more acres (Table 7).

In evaluating possibilities for processing, farms producing more than three acres will be of major concern. In 1959, these farms averaged about 7.0 acres but produced only about 60 percent of the total production in the state. The production from farms with at least 3 acres may have increased somewhat since 1959, but information concerning the amount of increase is not available.

Density of Production. The density of sweet potato production is a very important factor to be considered in determining the economic potential for sweet potato processing plants or other marketing activities. The production density for 1958 was calculated for the counties of North Carolina (Figure 6). There were 21 counties in 1958 which produced more than 10 hundredweight per 100 acres of total area. The heavier density counties were Johnston, Columbus, Pamlico and Chowan with more than 30 hundredweight per 100 acres. Counties with more than 20 hundredweight per 100 acres of land area were those listed above plus Martin, Edgecombe and Lenoir.

The total production density is important to processors but one must be aware that a processing plant may have access to a relatively small proportion of the total production within a given area. Recall the fact that North Carolina sweet potato producers sold less than 60 percent of total production in 1959. Secondly, processing plants must compete with the fresh market for the higher quality raw product and with farm uses for the canner grade.

Table 6. **Number of farms producing sweet potatoes and production, by size of enterprise, North Carolina, 1954 and 1959**

Size of sweet potato enterprise	Number of farms reporting		Percent of farms reporting		Sweet potato production							
					Total				Per farm		Per acre	
(acres harvested)	(number)		(percent)		(bushels)		(percent)		(bushels)		(bushels)	
	1954	1959	1954	1959	1954	1959	1954	1959	1954	1959	1954	1959
Less than 1[a]	82,013	39,793	87.8	84.8	1,126,909	733,629	31.3	19.2	13.7	18.4	c	c
1.0 - 1.9	6,783	3,448	7.3	7.4	664,695	436,460	18.4	11.3	98.0	126.6	90.8	117.2
2.0 - 2.9	2,243	1,472	2.4	3.1	421,945	382,779	11.7	10.0	188.1	260.0	91.2	125.8
3.0 - 9.9	2,090	1,806	2.2	3.9	905,480	1,133,908	25.1	29.6	433.2	627.8	108.3	142.5
10.0 - 24.9	195	280	.2	.6	412,825	623,217	11.5	16.3	2117.0	2225.7	104.0	162.2
25 or more	20	74	.1	.2	73,230	520,778	2.0	13.6	3661.5	7037.5	85.4	160.8
Total 1 or more[b]	11,331	7,080	12.2	15.2	2,478,175	3,097,142	68.7	80.0	218.7	437.4	98.6	142.1
Grand total[a]	93,344	46,873	100.0	100.0	3,605,084	3,830,771	100.0	100.0	38.6	81.7	c	c

[a] Includes farms for which bushels but not acreages were enumerated.
[b] Does not include farms with less than .1 acre or less than 20 bushels harvested.
[c] Not available.

Source: U. S. Bureau of the Census, Census of Agriculture, 1954 and 1959 (Washington: Government Printing Office, 1954 and 1959).

Table 7. Acres of sweet potatoes harvested and production on those farms harvesting 1 acre or more, by size of enterprise, North Carolina, 1954 and 1959

Size of sweet potato enterprise (acres harvested)	Farms reporting		Acres harvested						Production	
			Total				Per farm			
	(percent)		(number)		(percent)		(number)		(percent)	
	1954	1959	1954	1959	1954	1959	1954	1959	1954	1959
Less than 1[a]	-	-	4,341	3,495	-	-	c	c	-	-
1.0 - 1.9	59.9	48.7	7,315	3,723	29.1	17.1	1.1	1.1	26.8	14.1
2.0 - 2.9	19.8	20.8	4,627	3,042	18.4	14.0	2.1	2.1	17.0	12.4
3.0 - 9.9	18.4	25.5	8,364	7,953	33.3	36.5	4.0	4.4	36.5	36.6
10.0 - 24.9	1.7	4.0	3,969	3,842	15.8	17.6	20.4	13.7	16.7	20.1
25 or more	.2	1.0	857	3,237	3.4	14.8	42.9	43.7	3.0	16.8
Total 1 or more[b]	100.0	100.0	25,132	21,797	100.0	100.0	2.2	3.1	100.0	100.0
Grand total[a]	-	-	29,473	25,292	-	-	c	c	-	-

[a] Includes farms for which bushels but not acreages were enumerated.
[b] Does not include farms with less than .1 acre or less than 20 bushels harvested.
[c] Not available.

Source: U. S. Bureau of the Census, Census of Agriculture, 1954 and 1959 (Washington: Government Printing Office, 1954 and 1959).

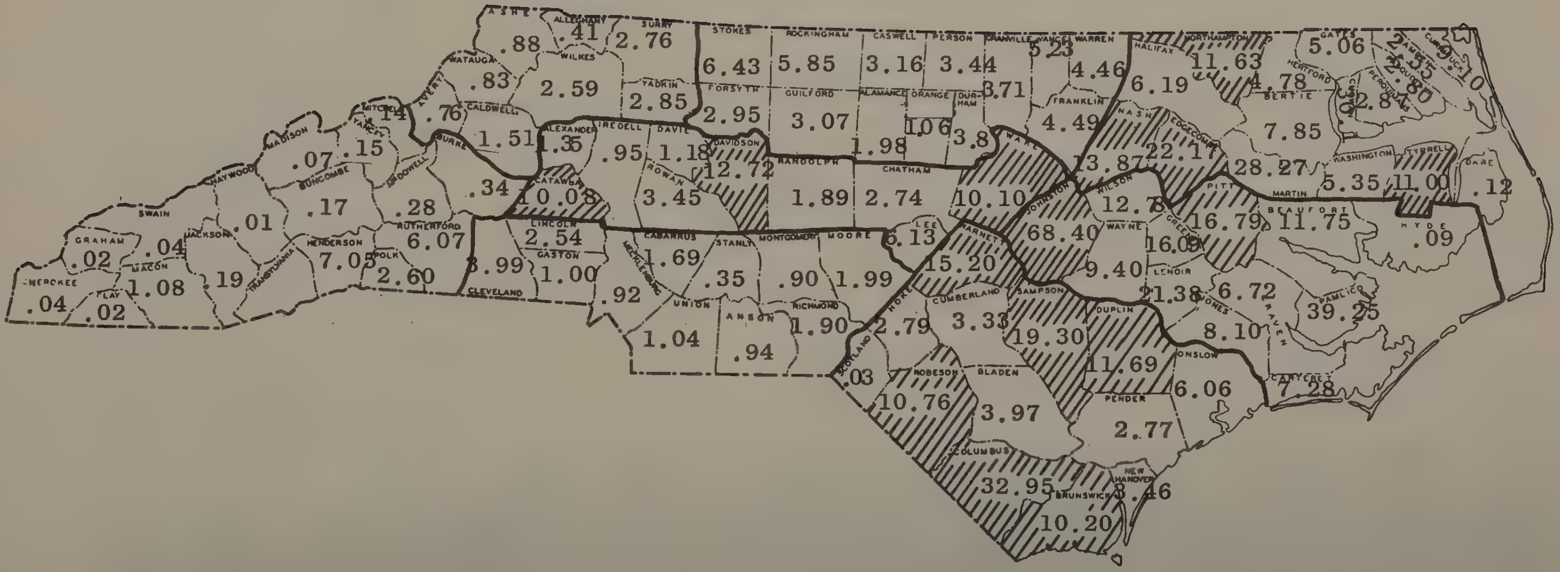


Figure 6. Average density of sweet potato production in North Carolina, 1958, in hundredweight per 100 acres of total area.

Assuming that producers continue their present marketing pattern, the most a processing plant could expect would be less than 60 percent of the total production. A particular example could be cited such as Johnston County which had a production density of 68.4 hundredweight per 100 acres of land area and a total production of 348,000 hundredweight in 1958. If a processing plant were located in Johnston County, and if it could plan on the average quantity sold of around 60 percent, the quantity available for processing would have been 208,800 hundredweight in 1958. This would represent an effective density of 41 hundredweight instead of the average density of 68 hundredweight per 100 acres of land area. These figures are still too high since a processing plant would not completely dominate the raw product market.

The importance of density is illustrated for different density rates in Appendix Table 10. Within a given radius of a fixed point representing a processing plant, the quantity produced doubles as the density doubles. From the data in Appendix Table 14, it is possible to estimate supply within a given radius for any desired density. Likewise, for a given density level, a marketing firm could determine the size of the supply area required to operate a plant at a given output.

For example, if a 10,000 pound per hour plant operates at full capacity and buys all potatoes grown in the surrounding area, the radius of the supply area would be affected by production density in the following way:

Production per 100 acres of land	600-hour season	1,400-hour season
5 cwt.	25 miles	37 miles
10 cwt.	17 miles	26 miles
20 cwt.	12 miles	19 miles
30 cwt.	10 miles	15 miles

MARKET OUTLETS AND PRICE TRENDS

Farm Disposition

Sweet potatoes can be disposed of by: (1) selling to the fresh market; (2) selling to processors; (3) selling for seed; (4) using in the farm household; (5) using for seed on farm where grown and (6) using for feed or discarding because of spoilage. Data on farm disposition in the United States show that about two-thirds of all sweet potatoes are sold off the farm (Appendix Table 11). In 1959 there were 12,850,000 hundredweight sold which represent about 68 percent of the total production. About 11 percent was used for household purposes; about 18 percent was used on the farm for feed or lost through shrinkage and other deterioration; and about 3 percent was used on the farm for seeding purposes.

The quantity of sweet potatoes used for each purpose has been decreasing. The quantity sold in 1959 represented a 19 percent decrease from 1919. Trends in the use of sweet potatoes from 1919 to 1959 include: (1) the quantity used for household purposes decreased to 2,102,000 hundredweight for a 87 percent reduction; (2) the quantity used on the farm for feed or for shrinkage and loss decreased to 3,332,000 hundredweight or a decline of 63 percent; and (3) the quantity used for seed purposes decreased to 581,000 hundredweight representing a decrease of 71 percent.

There was considerable variation among the twenty-two commercial states in the proportion going to different uses in 1959. The proportion used for seed varied from 1.6 percent for Missouri to 4.2 percent for Louisiana (Appendix Table 12). For North Carolina, it was 2.7 percent for this use. The proportion going for feed, shrinkage, and loss had a much larger range -- 5.2 percent for Kansas to 32.1 percent for South Carolina. North Carolina used 22 percent of its sweet potatoes for these purposes. A very wide range existed among states in the proportion of sweet potatoes used for on-farm household purposes. California with .4 percent of its sweet potatoes used was low and Kentucky with 63.3 percent was high in household use. North Carolina used 16.4 percent of its production for on-farm household consumption.

Off-farm sales also varied considerably among states. Kentucky sold only 23.9 percent while Kansas sold a high of 88.5 percent of its production. North Carolina sold 58.8 percent which was somewhat less than the national average of 68.1 percent. Other states with a relatively high proportion of their sweet potatoes sold were: New Jersey, California, Maryland, Virginia, Texas and Oklahoma. States with a very low proportion of their sweet potatoes sold in 1958 were: Kentucky, Tennessee, South Carolina and Alabama. These states had a relatively large proportion of their sweet potatoes used for on-farm household consumption.

Trends in Sweet Potato Prices, Value of Production and Sales

The average price of sweet potatoes in the United States has varied widely over the last several decades (Figure 7). It has ranged from a low of $.85 per hundredweight in 1932 to a high of $5.99 per hundredweight in 1952. The low price of 1932 corresponds with the peak production year and the high price of 1952 follows the low production year of 1951. The average price in North Carolina follows the same general pattern. It was slightly lower than the average for the United States until 1944. Since 1944, it has been somewhat higher than the average for the United States.

The average price varies considerably among states (Appendix Table 13). For example, Louisiana farmers received only $1.55 per hundredweight while California farmers

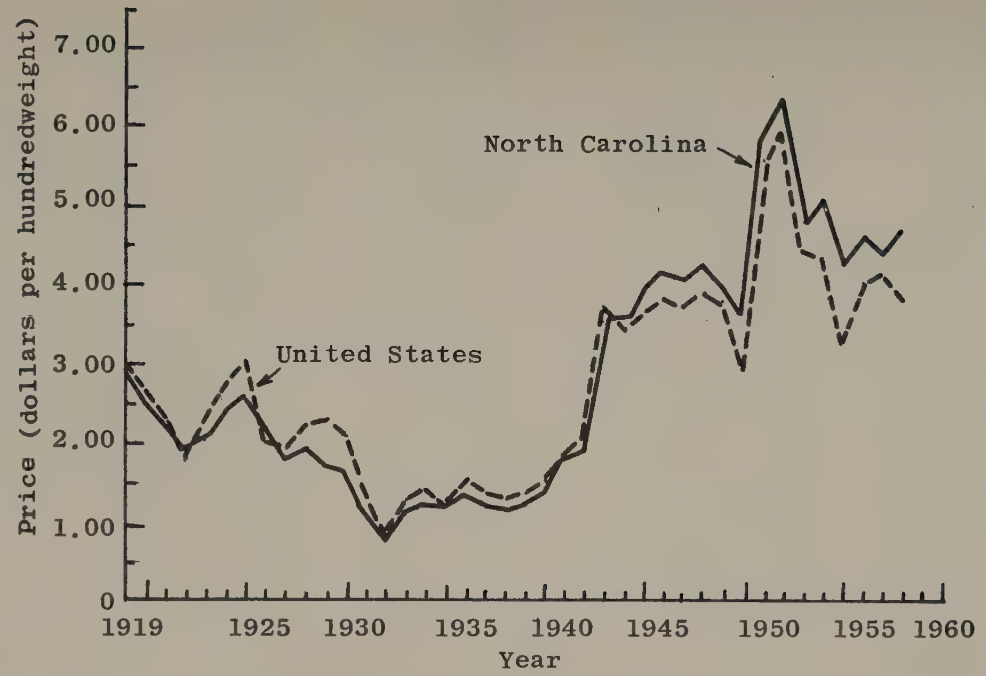


Figure 7. Season average price per hundredweight received by farmers, 1919-1959

Source: *Sweet Potatoes, Estimates in Hundredweight, by States, 1868-53*, U. S. Department of Agriculture, Statistical Bul. No. 237, 1958; *Potatoes and Sweet Potatoes, Revised Estimates, by States, 1949-55*, Statistical Bul. No. 190, August, 1956, and *Statistical Abstract*, 1959, Bureau of Census, U.S. Department of Commerce.

received $7.37 per hundredweight in 1959. Virginia also received a very low price for its sweet potatoes.

Geographic location seems to be important in determining the average price received by states. States near industrial areas tended to receive higher prices than states that were located farther away. Also, states that process sweet potatoes in volume such as Louisiana and Virginia tended to have lower average prices.

Of the 18 states reporting value of production in 1959, North Carolina had the largest value with 9,325,000 dollars (Appendix Table 14). Missouri was low with only 353,000 dollars. California ranked second with 7,186,000 dollars. Louisiana, the leader in value of production for many years, dropped to third with 6,952,000 dollars.

The value of sales in the United States has decreased since the 1952 peak (Appendix Table 15). It has decreased from 52,738,000 dollars in 1952 to 41,816,000 dollars in 1959. Value of sales in North Carolina has been relatively constant with the exception of 1951 in which it was relatively low. California was the leading state in value of sales in 1959. Louisiana was high before 1959, but the value of sales was relatively unstable in Louisiana.

Possibilities for Expanding Demand

Consumption of a farm product can sometimes be increased by offering the consumer a product that is attractive and uniform. Sweet potatoes are no exception. In the opinion of many marketing specialists, wholesalers, and retailers, the consumption of sweet potatoes could be increased considerably by offering the consumer a more attractive package and a more uniform product.

Some indication of recent shifts in the consumption of sweet potatoes is provided by a comparison of data on annual per capita consumption of sweet potatoes and Irish potatoes. For twenty years or more, the average annual per capita consumption of sweet potatoes in the United States has been much less than Irish potatoes. In 1959, the estimated per capita consumption of sweet potatoes was only 6.6 pounds (Figure 8). Per capita consumption of Irish potatoes was 100 pounds. For both Irish and sweet potatoes per capita consumption has been decreasing since 1940, but Irish potatoes has been gaining relative to sweet potatoes. For example, in 1940 there were 7.6 pounds of Irish potatoes consumed for every pound of sweet potatoes, but in 1958, there were 15.1 pounds of Irish potatoes consumed per pound of sweet potatoes. Consumers may be substituting Irish for sweet potatoes.

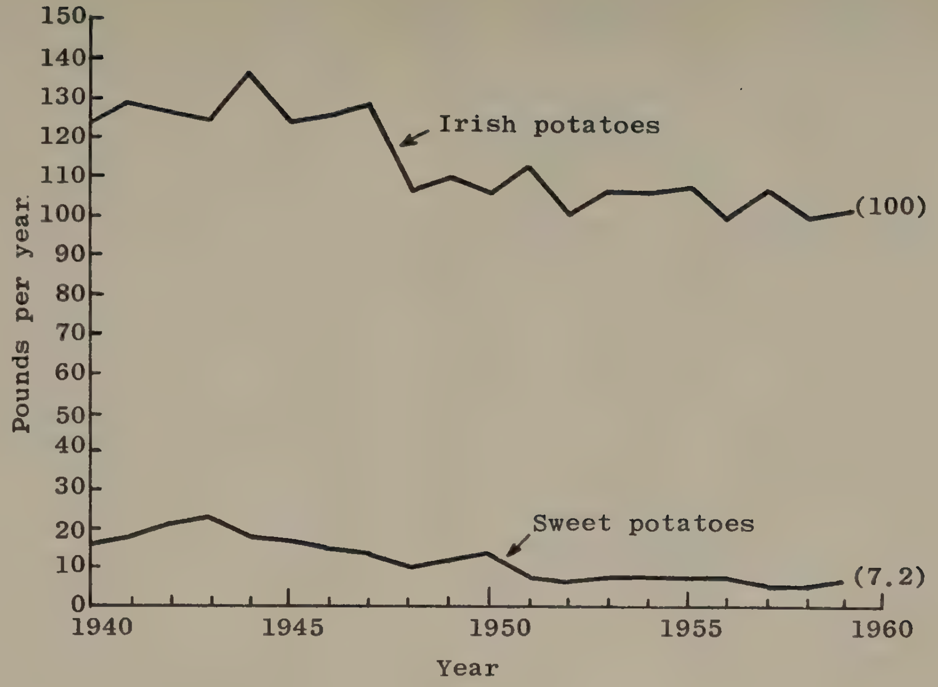


Figure 8. Per capita consumption of Irish and sweet potatoes, United States, 1940-58

Source: Supplement for 1956 to *Consumption of Food in the United States*, 1909-52, Agriculture Handbook No. 62, USDA, AMS, Washington, D.C., September, 1957; *Statistical Abstract*, 1960, Bureau of the Census, U. S. Department of Commerce, Washington.

An examination of retail price indexes provides one possible explanation for the reduction of sweet potato per capita consumption (Figure 9). Using 1947-49 prices as a base, the index for sweet potatoes has been somewhat higher than the index for all foods since 1943 except for the six years 1945, 1947, 1948, 1950, 1951, and 1956. Of the above years, the index for sweet potato prices was higher than the index for Irish potatoes except for the two years 1948 and 1956. Since 1951, sweet potato prices have been relatively high compared to all foods as well as Irish potatoes.

Even though sweet potato farm prices have been increasing since 1944, there is a relatively large margin between retail price and average farm price for Irish potatoes. (Figure 10). However, some of the difference in margin may be due to two factors: (1) sweet potatoes require curing between the farm and the retail stores that is not necessary for Irish and (2) a smaller total volume with high seasonal variation is produced and sold.

Foremost among the ways in which consumption might be increased would be the production, grading, packing and distribution of a uniform high quality fresh and cured product. However, field-run sweet potatoes are not very uniform in either size or quality. Thus the sale of a quality fresh or cured product alone might entail serious losses to the industry. Other methods that would help include improved varieties, better handling methods and an aggressive merchandising program. Making sweet potatoes available during the entire year might increase consumption by either of two methods: (1) improving the methods of curing and storing the fresh potatoes and/or (2) processing potatoes into relatively nonperishable forms.

The processing of sweet potatoes appears to offer possibilities for expanding consumption. It may also provide the industry with a method of disposing of off-size or poor quality sweet potatoes. The principal processes include dehydration, freezing and canning.

Data available concerning processed sweet potatoes indicate that canned sweet potato consumption has increased from .2 pounds in 1940 to .9 pounds in 1960 (Appendix Table 16). Processing on a farm weight basis has increased from 631,000 hundredweight in 1941 to 1,820,000 hundredweight in 1960. Data concerning dehydrated sweet potatoes were only available for 1942-46, but a large quantity of sweet potatoes was processed in 1945. New processes for flaking potatoes offer promise of adding to current levels of potato consumption, although fresh consumption will continue to be the primary outlet for some time to come.

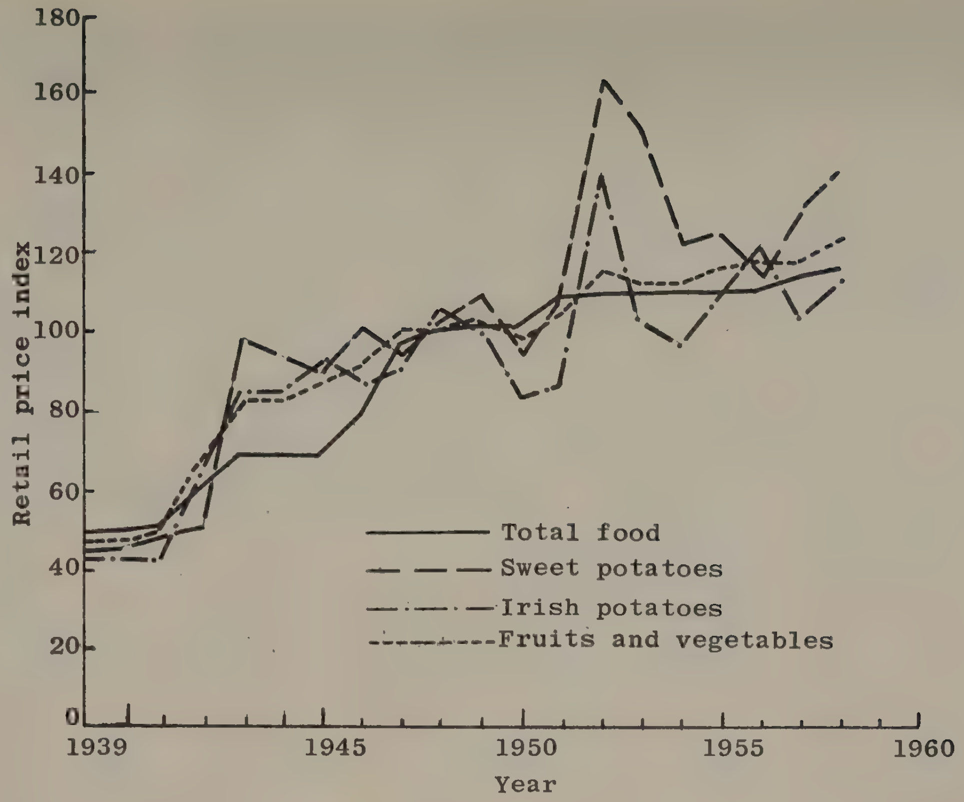


Figure 9. Retail price indexes for all foods, fruits and vegetables, Irish potatoes and sweet potatoes, United States, 1939-1958 (1947-49 = 100)

Source: Retail Prices of Food, Bureau of Labor Statistics, U. S. Department of Labor.

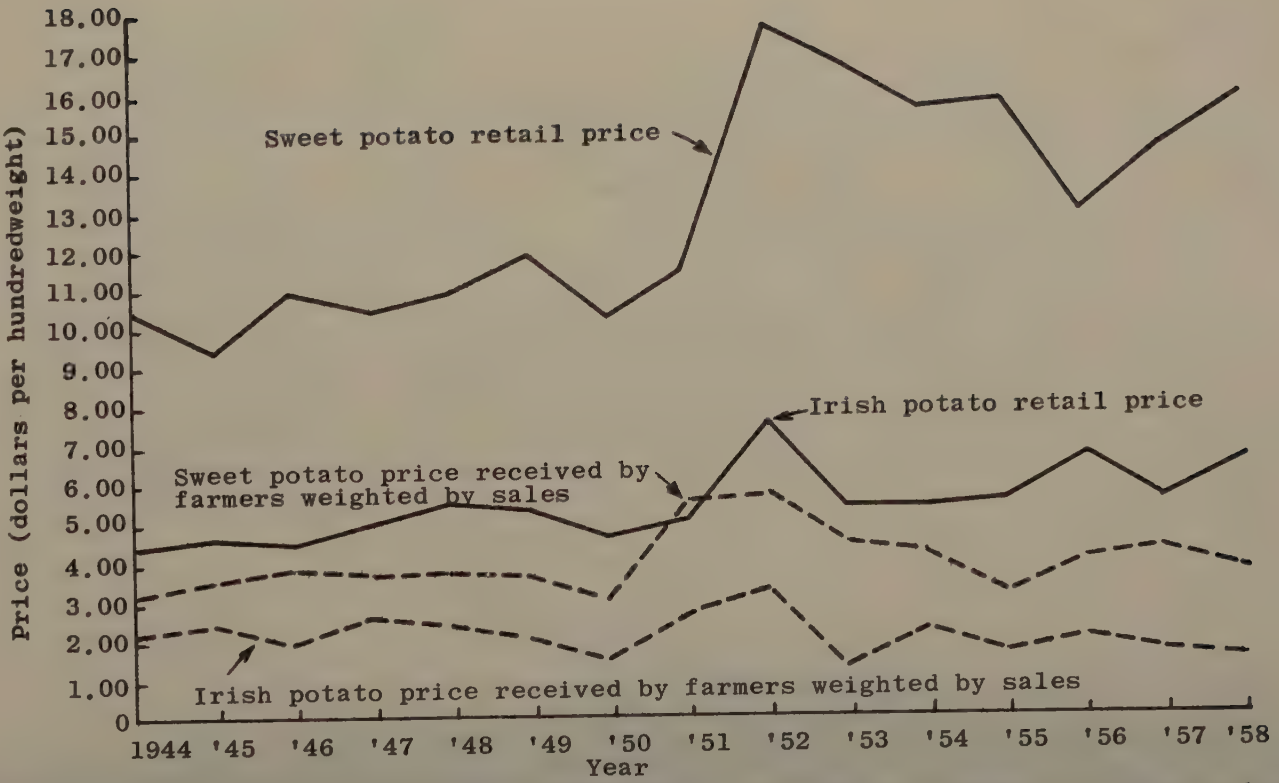


Figure 10. Retail price and average farm price received by farmers for Irish and sweet potatoes, United States, 1944-58

Source: Potatoes and Sweet Potatoes Revised Estimates, by States, 1949-55, U. S. Department of Agriculture, Statistical Bul. No. 190, 1956, Agricultural Statistics, 1959, U. S. Department of Agriculture, Washington, and Retail Prices of Food, Bureau of Labor Statistics, U. S. Department of Labor.

CONCLUSIONS

The supply of green sweet potatoes is a very important factor in determining the economic possibilities of expanding the sweet potato processing industry. This report provides information which should be useful in determining the potential supply of raw sweet potatoes available for processing in North Carolina.

A review of historical patterns of production, prices, disposition and value was made for the purpose of providing planning guides. Historically, North Carolina has been a large sweet potato producing state, ranking second in the nation. This might indicate that the processing industry has excellent possibilities of expansion in North Carolina and might well supply green potatoes to more than the four plants which were in operation in 1961. But factors other than total production are also important in determining the quantity of green potatoes available for processing. Some of these factors are considered in comparing the two marketing alternatives.

Enterprise budgets were used to compare returns to land, operator's labor and management from processing sales with returns from combined fresh and processing market sales. Among the variables considered were yield, price, production, harvesting and assembly costs, size of truck and length of haul. Price mapping was used to illustrate the prices necessary in the two markets to yield equal returns.

Growing expenses were calculated to be $121.45 for each method. Yield was assumed to depend on quality of land, operator's labor and management skill. Therefore, growing expenses did not vary with yield. Fixed expenses were also independent of yield and amounted to $14.29. These expenses were the same under both methods of marketing.

Harvesting and grading expenses varied with yield and method of marketing. The difference between the two methods of marketing was about $0.75 per hundredweight with sales of both fresh and processing potatoes being the most expensive. This was due to the additional labor required for grading and more expensive containers used for fresh market sales.

Assembly costs per hundredweight varied with yield, size of truck and length of haul but not with the method of marketing. Since assembly costs do not vary between the two methods of marketing, the total cost of production and assembly differs only by the difference in harvesting and grading. Therefore, the $0.75 differential in costs represents the break-even level in price for the two methods. Sweet potato producers would be indifferent to the market selected if the average price for combined sales was $0.75 more per hundredweight than the processing price, providing that each market was the same distance from the point of production.

This study points out that for profitable production the yield per acre must be greater than the current state average. Under both methods of marketing, the yield per acre which a producer should consider as minimum for planning purposes appears to be 150 hundredweight per acre. This yield enables sweet potatoes to compete successfully for land and operator's labor with other farm enterprises at current market prices.

The minimum prices of sweet potatoes required to yield positive returns with a 150 hundredweight yield are about $1.50 per hundredweight for processing and about $2.25 per hundredweight in the combined market. However, a minimum price of $2.00 in the processing market and $2.75 in the combined market would appear to be necessary for sweet potatoes to compete successfully with other enterprises for the fixed factors of production. The combined market price has historically been higher than $2.75 per hundredweight but processors have not generally paid more than $2.00.

The potential supply of green potatoes available for processing may be a relatively small portion of total production in North Carolina. In the past, less than 60 percent of North Carolina total production has entered marketing channels. Also, processors have not been able or willing to pay the price necessary to be competitive with the fresh market outlets. If processors are not able to meet the price offered by the fresh market, the only potential supply remaining open to processors appears to be the canner grade of potatoes. Even for these potatoes they must compete with livestock feeders who evidently consider that sweet potatoes have a positive value as a livestock feed.

One encouraging fact concerning the possibilities of expanding the processing industry in North Carolina is that production is concentrated in three relatively small areas of the state. This tends to reduce assembly costs and to increase volume for plants in these areas. The possibilities of establishing and successfully operating a processing plant are greater in these commercial areas than in other locations in the state. The possibilities of further expanding production to meet future demands for green sweet potatoes are also better in these commercial areas. Further research is under way to determine the number, size and location of plants that would represent an efficiently organized processing industry within the sweet potato producing areas of North Carolina.

Appendix Table 1. Costs of transporting sweet potatoes from field to market, assuming varying lengths of haul and sizes of truck

Size of truck[a]	Amount[b]		Length of trip in miles (round trip)					
	Per load	Per mile	5	10	15	20	25	30
	(dol.)	(dol.)	(dollars per load)					
1/2-ton								
Variable costs	0	.056	.280	.560	.840	1.120	1.400	1.680
Average fixed costs[c]	0	.024	.120	.240	.360	.480	.600	.720
Labor costs	1.28	.068	1.620	1.960	2.300	2.640	2.980	3.320
Total	1.28	.148	2.020	2.760	3.500	4.240	4.980	5.720
1-ton								
Variable costs	0	.063	.320	.630	.950	1.260	1.580	1.890
Average fixed costs[c]	0	.026	.130	.260	.390	.520	.650	.780
Labor costs	2.57	.068	2.910	3.250	3.550	3.930	4.270	4.610
Total	2.57	.157	3.360	4.140	4.930	5.710	6.500	7.280
1 1/2 ton								
Variable costs	0	.069	.350	.690	1.040	1.380	1.730	2.070
Average fixed costs[c]	0	.028	.140	.280	.420	.560	.700	.840
Labor costs	3.86	.068	4.200	4.540	4.880	5.220	5.560	5.900
Total	3.86	.165	4.690	5.510	6.340	7.160	7.990	8.810
2-ton								
Variable costs	0	.076	.380	.760	1.140	1.520	1.900	2.280
Average fixed costs[c]	0	.032	.160	.320	.480	.640	.800	.960
Labor costs	5.14	.068	5.480	5.820	6.160	6.500	6.840	7.180
Total	5.14	.176	6.020	6.900	7.780	8.660	9.540	10.420

[a] N. C. License Bureau indicates typical net weight loads as follows: 1/2-ton, 1600 pounds; 1-ton, 2800 pounds; 1 1/2-ton, 4000 pounds; 2-ton, 5200 pounds.

[b] Calculated on basis of 1/2-, 1-, 1 1/2- and 2-ton trucks, driven 10,000 miles per year, charging 50 percent of the truck's use to the sweet potato enterprise.

[c] See Table 5 for detailed descriptions.

Appendix Table 2. Assembly costs of sweet potatoes with varying sizes of trucks, length of haul and yield

Size of truck and length of haul	Yield of marketable potatoes				
	50	100	150	200	50-200
	(dollars per acre)				(dollars per cwt.)
1/2-ton					
5 miles	6.31	12.62	18.93	25.24	.126
10 miles	8.63	17.26	25.89	34.52	.175
15 miles	10.94	21.88	32.82	43.76	.219
20 miles	13.25	26.50	39.75	53.00	.265
25 miles	15.56	31.12	46.68	62.24	.311
30 miles	17.88	35.76	53.64	71.52	.358
1-ton					
5 miles	6.00	12.00	18.00	24.00	.120
10 miles	7.39	14.78	22.17	29.56	.148
15 miles	8.80	17.60	26.40	35.20	.176
20 miles	10.19	20.38	30.57	40.76	.204
25 miles	11.60	23.20	34.80	46.40	.232
30 miles	12.99	25.98	38.97	51.96	.260
1 1/2-ton					
5 miles	5.86	11.72	17.58	23.44	.117
10 miles	6.89	13.78	20.67	27.56	.138
15 miles	7.93	15.86	23.79	31.72	.159
20 miles	8.95	17.90	26.85	35.80	.179
25 miles	9.99	19.98	29.97	39.96	.200
30 miles	11.01	22.02	33.03	44.04	.220
2-ton					
5 miles	5.79	11.58	17.37	23.16	.116
10 miles	6.64	13.28	19.92	26.56	.133
15 miles	7.48	14.96	22.44	29.92	.150
20 miles	8.33	16.66	24.99	33.32	.167
25 miles	9.18	18.36	27.54	36.72	.184
30 miles	10.02	20.04	30.06	40.08	.200

Appendix Table 3. Net returns to land, operator's labor, and management at varying plant prices, yields, and length of haul with one and one-half ton truck; processing market only

Distance from farm to plant	Plant price (dollars per hundredweight)				
	.50	1.00	1.50	2.00	2.50
(one way)	(dollars per acre)				
2 1/2 miles					
50 cwt./acre	-140.50	-115.50	-90.50	-65.50	-40.50
100 cwt./acre	-143.91	- 93.91	-43.91	6.09	56.09
150 cwt./acre	-147.32	- 72.32	2.68	77.68	152.68
200 cwt./acre	-150.73	- 50.73	49.27	149.27	249.27
5 miles					
50 cwt./acre	-141.53	-116.53	-91.53	-66.53	-41.53
100 cwt./acre	-145.97	- 95.97	-45.97	4.03	54.03
150 cwt./acre	-150.41	- 75.41	- .41	74.59	149.59
200 cwt./acre	-154.85	- 54.85	45.15	145.15	245.15
7 1/2 miles					
50 cwt./acre	-142.57	-117.57	-92.57	-67.57	-42.57
100 cwt./acre	-148.05	- 98.05	-48.05	1.95	51.95
150 cwt./acre	-153.53	- 78.53	- 3.53	71.47	146.47
200 cwt./acre	-159.01	- 59.01	40.99	140.99	240.99
10 miles					
50 cwt./acre	-143.59	-118.59	-93.59	-68.59	-43.59
100 cwt./acre	-150.09	-100.09	-50.09	.09	50.09
150 cwt./acre	-156.59	- 81.59	- 6.59	68.41	143.41
200 cwt./acre	-163.09	- 63.09	36.91	136.91	236.91
12 1/2 miles					
50 cwt./acre	-144.63	-119.63	-94.63	-69.63	-44.63
100 cwt./acre	-152.17	-102.17	-52.17	- 2.17	47.83
150 cwt./acre	-159.71	- 84.71	- 9.71	65.29	140.29
200 cwt./acre	-167.25	- 67.25	32.75	132.75	232.75
15 miles					
50 cwt./acre	-145.65	-120.65	-95.65	-70.65	-45.65
100 cwt./acre	-154.21	-104.21	-54.21	- 4.21	45.79
150 cwt./acre	-162.77	- 87.77	-12.77	62.23	137.23
200 cwt./acre	-171.33	- 71.33	28.67	128.67	228.67

Appendix Table 4. Net returns to land, operator's labor and management at varying plant prices, yields, and length of haul with a two-ton truck; processing market only

Distance from farm to plant	Plant price (dollars per hundredweight)				
	.50	1.00	1.50	2.00	2.50
(one way)	(dollars per acre)				
2 1/2 miles					
50 cwt./acre	-140.43	-115.43	-90.43	-65.43	-40.43
100 cwt./acre	-143.77	- 93.77	-43.77	6.23	56.23
150 cwt./acre	-147.11	- 72.11	2.89	77.89	152.89
200 cwt./acre	-150.45	- 50.45	49.55	149.55	249.55
5 miles					
50 cwt./acre	-141.28	-116.28	-91.28	-66.28	-41.28
100 cwt./acre	-145.47	- 95.47	-45.47	4.53	54.53
150 cwt./acre	-149.66	- 74.66	.34	75.34	150.34
200 cwt./acre	-153.85	- 53.85	46.15	146.15	246.15
7 1/2 miles					
50 cwt./acre	-142.12	-117.12	-92.12	-67.12	-42.12
100 cwt./acre	-147.15	- 97.15	-47.15	2.85	52.85
150 cwt./acre	-152.18	- 77.18	- 2.18	72.82	147.82
200 cwt./acre	-157.21	- 57.21	42.79	142.79	242.79
10 miles					
50 cwt./acre	-142.97	-117.97	-92.97	-67.97	-42.97
100 cwt./acre	-148.85	- 98.85	-48.85	1.15	51.15
150 cwt./acre	-154.73	- 79.73	- 4.73	70.27	145.27
200 cwt./acre	-160.61	- 60.61	39.39	139.39	239.39
12 1/2 miles					
50 cwt./acre	-143.82	-118.82	-93.82	-68.82	-43.82
100 cwt./acre	-150.55	-100.55	-50.55	- .55	49.45
150 cwt./acre	-157.28	- 82.28	- 7.28	67.72	142.72
200 cwt./acre	-164.01	- 64.01	35.99	135.99	235.99
15 miles					
50 cwt./acre	-144.66	-119.66	-94.66	-69.66	-44.66
100 cwt./acre	-152.23	-102.23	-52.23	- 2.23	47.77
150 cwt./acre	-159.80	- 84.80	- 9.80	65.20	140.20
200 cwt./acre	-167.37	- 67.37	32.63	132.63	232.63

Appendix Table 5. Net returns to land, operator's labor and management per acre at varying average prices, yields, and length of haul with a one and one-half ton truck; processing and fresh markets combined

Distance from farm to market	Average market price (dol. per cwt.)			
	2.00	3.00	4.00	5.00
(one way)	(dollars per acre)			
2 1/2 miles				
50 cwt./acre	-102.21	-52.21	- 2.21	47.79
100 cwt./acre	- 67.33	32.67	132.67	232.67
150 cwt./acre	- 32.45	117.55	267.55	417.55
200 cwt./acre	2.43	202.43	402.43	602.43
5 miles				
50 cwt./acre	-103.24	-53.24	- 3.24	46.76
100 cwt./acre	- 69.39	30.61	130.61	230.61
150 cwt./acre	- 35.54	114.46	264.46	414.46
200 cwt./acre	- 1.69	198.31	398.31	598.31
7 1/2 miles				
50 cwt./acre	-104.27	54.27	- 4.27	45.73
100 cwt./acre	- 71.45	28.55	128.55	228.55
150 cwt./acre	- 38.63	111.37	261.37	411.37
200 cwt./acre	- 5.81	194.19	394.19	594.19
10 miles				
50 cwt./acre	-105.30	-55.30	- 5.30	44.70
100 cwt./acre	- 73.51	26.49	126.49	226.49
150 cwt./acre	- 41.72	108.28	258.28	408.28
200 cwt./acre	- 9.93	190.07	390.07	590.07
12 1/2 miles				
50 cwt./acre	-106.33	-56.33	- 6.33	43.67
100 cwt./acre	- 75.57	24.43	124.43	224.43
150 cwt./acre	- 44.81	105.19	255.19	405.19
200 cwt./acre	- 14.05	185.95	385.95	585.95
15 miles				
50 cwt./acre	-107.36	-57.36	- 7.36	42.64
100 cwt./acre	- 77.63	22.37	122.37	222.37
150 cwt./acre	- 47.90	102.10	252.10	402.10
200 cwt./acre	- 18.17	181.83	381.83	581.83

Appendix Table 6. Net returns to land, operator's labor and management per acre at varying average prices, yields, and length of haul with a two-ton truck; processing and fresh markets combined

Distance from farm to market	Average market price (dol. per cwt.)			
	2.00	3.00	4.00	5.00
(one way)	(dollars per acre)			
2 1/2 miles				
50 cwt./acre	-102.14	-52.14	- 2.14	47.86
100 cwt./acre	- 67.19	32.81	132.81	232.81
150 cwt./acre	- 32.24	117.76	267.76	417.76
200 cwt./acre	2.71	202.71	402.71	602.71
5 miles				
50 cwt./acre	-102.99	-52.99	- 2.99	47.01
100 cwt./acre	- 68.89	31.11	131.11	231.11
150 cwt./acre	- 34.79	115.21	265.21	415.21
200 cwt./acre	- .69	199.31	399.31	599.31
7 1/2 miles				
50 cwt./acre	-103.83	-53.83	- 3.83	46.17
100 cwt./acre	- 70.57	29.43	129.43	229.43
150 cwt./acre	- 37.31	112.69	262.69	412.69
200 cwt./acre	- 4.02	195.98	395.98	595.98
10 miles				
50 cwt./acre	-104.68	-54.68	- 4.68	45.32
100 cwt./acre	- 72.27	27.73	127.73	227.73
150 cwt./acre	- 39.86	110.14	260.14	410.14
200 cwt./acre	- 7.45	195.55	395.55	595.55
12 1/2 miles				
50 cwt./acre	-105.53	-55.53	- 5.53	44.47
100 cwt./acre	- 73.97	26.03	126.03	226.03
150 cwt./acre	- 42.41	107.59	257.59	407.59
200 cwt./acre	- 10.85	189.15	389.15	589.15
15 miles				
50 cwt./acre	-106.37	-56.37	- 6.37	43.63
100 cwt./acre	- 75.65	24.35	124.35	224.35
150 cwt./acre	- 44.93	105.07	255.07	405.07
200 cwt./acre	- 14.21	185.79	385.79	585.79

Appendix Table 7. Sweet potatoes: Acreage, yield, and production, United States, 1919-1961

Year	Acreage harvested	Yield per acre harvested	Production
	(1,000 acres)	(cwt.)	(1,000 cwt.)
1919	791.0	54.4	43,050
1920	767.0	55.0	42,349
1921	817.0	49.5	40,539
1922	817.0	52.8	43,101
1923	674.0	52.2	35,129
1924	564.0	43.8	24.686
1925	636.0	43.3	27,576
1926	645.0	54.0	34,815
1927	724.0	53.8	38,993
1928	636.0	57.2	32,548
1929	647.0	55.3	35,758
1930	670.0	44.8	30,017
1931	854.0	43.3	37,023
1932	1059.0	45.0	47,627
1933	907.0	45.3	41,040
1934	959.0	44.6	42,722
1935	944.0	47.4	44,687
1936	769.0	42.7	32,871
1937	768.0	48.8	37,479
1938	793.0	47.6	37,732
1939	728.0	46.6	33,959
1940	647.7	43.9	28,434
1941	730.9	47.0	34,384
1942	687.0	42.4	36,008
1943	856.6	45.7	39,128
1944	726.0	51.7	37,538
1945	645.9	52.1	33,692
1946	637.0	52.5	33,454
1947	546.6	49.9	27,303
1948	455.3	52.0	23,702
1949	472.1	52.5	24,804
1950	489.4	55.7	27,269
1951	312.0	51.3	15,998
1952	321.5	49.9	16,040
1953	343.0	55.4	18,998
1954	332.1	51.8	17,198
1955	341.6	63.3	21,608
1956	275.8	63.0	17,381
1957	273.8	65.9	18,057
1958	255.5	68.8	17,571
1959	256.6	73.5	18,865
1960	203.0	77.1	15,636
1961[a]	200.0	76.1	15,198

[a] Preliminary estimates.

Appendix Table 8. Sweet potatoes: Acreage and production by state, 1949-58 average, 1959 and 1960

State	Acreage harvested			Production		
	Average 1949-58	1959	1960	Average 1949-58	1959	Indicated 1960
	(1,000 acres)			(1,000 cwt.)		
South Atlantic states:						
Virginia	17.3	20.2	20.0	1,386	2,020	2,040
North Carolina	42.5	31.0	25.0	2,626	2,480	2,250
South Carolina	25.9	13.0	9.0	1,316	741	495
Georgia	25.5	16.0	10.0	1,076	1,056	480
Florida	4.0	2.3	1.2	171	120	60
Subtotal	115.2	82.5	65.2	6,557	6,417	5,325
Other states:						
New Jersey	15.8	15.0	14.5	1,385	1,260	1,450
Missouri	2.5	1.3	1.5	138	124	98
Kansas	1.1	1.2	1.3	59	96	117
Maryland	5.1	4.3	4.0	524	568	540
Kentucky	5.8	2.8	4.2	294	188	221
Tennessee	12.5	8.5	7.0	687	722	490
Alabama	20.5	13.0	10.0	906	754	570
Mississippi	24.5	18.0	16.0	1,122	1,206	816
Arkansas	7.1	4.9	3.7	324	353	240
Louisiana	88.4	69.0	65.0	4,872	4,485	3,770
Oklahoma	2.8	1.7	1.7	132	110	110
Texas	29.2	20.0	17.0	1,337	1,460	1,020
California	11.7	13.0	12.0	837	975	900
United States	344.2	256.6	223.0	19,302	18,865	10,342

Appendix Table 9. Sweet potatoes: Acreage, yield and production, North Carolina, 1941-50 average and 1950-1961

Year	Acreage harvested	Yield per acre	Production
	(thousand acres)	(cwt.)	(1,000 cwt.)
1941-50 average	65	53	3,425
1950	62	55	3,410
1951	37	47	1,739
1952	39	50	1,950
1953	46	55	2,509
1954	41	57	2,337
1955	40	60	2,400
1956	36	66	2,376
1957	39	70	2,730
1958	31	75	2,325
1959	31	80	2,480
1960	24	100	2,400
1961[a]	22	110	2,420

[a] Preliminary.

Appendix Table 10. Production density in hundredweight per 100 acres of land area assuming different radii from a fixed point

Radius from a given point	Area contained in circle with given radius	Production density (cwt. per 100 acres)							
		5	10	20	30	40	50	60	70
(miles)	(sq. miles)				(hundredweight)				
1	3.1	101	201	402	603	804	1,005	1,206	1,407
5	78.5	2,514	5,027	10,053	15,080	20,106	25,133	30,159	35,186
10	314.2	10,053	20,106	40,213	60,319	80,425	100,531	120,637	140,744
15	706.9	22,669	45,239	90,478	135,717	180,956	226,195	271,434	316,673
20	1256.6	40,213	80,425	160,850	241,275	321,700	402,125	482,550	562,975
25	1963.5	62,832	125,664	251,328	376,992	502,656	628,320	753,984	879,648
30	2827.4	90,478	180,956	361,912	542,869	723,825	904,781	1,085,737	1,266,694
35	3848.5	123,150	246,300	492,600	738,900	985,200	1,231,500	1,477,800	1,724,100
40	5026.6	160,850	321,700	643,400	965,100	1,286,800	1,608,500	1,930,200	2,251,900
50	7854.0	301,330	602,660	1,205,320	1,807,980	2,410,640	3,013,300	3,615,960	4,218,620
60	11309.8	361,920	723,840	1,447,680	2,171,520	2,895,360	3,619,200	4,343,040	5,066,880
70	15393.8	492,600	985,200	1,970,400	2,955,600	3,940,800	4,926,000	5,911,200	6,896,400
80	20106.2	643,390	1,286,780	2,573,560	3,860,340	5,147,120	6,433,900	7,720,680	9,007,460
90	25447.0	814,305	1,628,610	3,257,220	4,885,830	6,514,440	8,143,050	9,771,660	11,400,270
100	31416.0	1,005,310	2,010,620	4,021,240	6,031,860	8,042,480	10,053,100	12,063,720	14,074,340

Appendix Table 11. Farm disposition of sweet potatoes, United States, 1919-1959

Year	Used on farm where grown			Sold
	For seed	Feed shrinkage and loss	For household use	
	(1,000 hundredweight)			
1919	2,004	9,003	16,162	15,881
1920	2,112	8,681	15,580	15,976
1921	2,113	8,140	15,332	14,954
1922	1,816	9,159	15,542	16,584
1923	1,523	6,824	12,947	13,835
1924	1,535	3,730	9,248	10,173
1925	1,596	4,142	10,104	11,734
1926	1,854	6,123	12,045	14,793
1927	1,684	7,883	13,606	15,820
1928	1,599	5,802	11,769	13,378
1929	1,620	7,005	12,596	14,537
1930	1,827	5,229	11,015	11,946
1931	2,393	6,372	13,413	14,845
1932	2,250	10,708	17,599	17,070
1933	2,367	8,393	15,339	14,941
1934	2,324	9,056	16,580	14,762
1935	1,698	9,909	16,718	16,362
1936	1,642	5,964	12,426	12,839
1937	1,693	7,526	13,971	14,289
1938	1,564	7,889	14,016	14,263
1939	1,395	6,596	12,514	13,454
1940	1,554	4,665	10,461	11,754
1941	1,475	6,882	12,134	13,893
1942	1,818	7,137	12,069	14,984
1943	1,581	8,682	13,074	15,791
1944	1,394	7,456	11,712	16,976
1945	1,349	6,210	10,871	15,262
1946	1,173	6,067	10,408	15,266
1947	937	6,394	8,544	11,428
1948	1,037	4,644	7,402	10,619
1949	1,140	4,932	7,235	11,497
1950	711	6,757	6,860	12,941
1951	728	2,375	4,631	8,264
1952	786	2,204	4,246	8,804
1953	787	2,964	4,359	10,888
1954	781	2,623	4,142	9,652
1955	673	3,996	4,404	12,535
1956	653	2,506	3,320	10,902
1957	661	3,317	2,959	11,120
1958	692	2,398	2,498	11,983
1959	581	3,332	2,102	12,850

Appendix Table 12. Sweet potato disposition, by state, 1959

State	Used on farm where grown						Sales		Total
	Seed		Feed shrinkage and loss		Household use				
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
	(1,000 cwt.)		(1,000 cwt.)		(1,000 cwt.)		(1,000 cwt.)		(1,000 cwt.)
New Jersey	33	2.6	204	16.2	9	.7	1,014	80.4	1,260
Missouri	2	1.6	7	5.4	40	32.3	75	60.5	124
Kansas	3	3.1	5	5.2	3	3.1	85	88.5	96
Maryland	11	1.9	42	7.4	14	2.5	501	88.2	568
Virginia	60	3.0	172	8.5	99	4.9	1,689	83.6	2,020
North Carolina	67	2.7	546	22.0	408	16.4	1,459	58.8	2,480
South Carolina	18	2.4	238	32.1	160	21.6	325	43.9	741
Georgia	25	2.4	248	23.5	128	12.1	655	62.0	1,056
Florida	3	2.5	18	15.0	10	8.3	89	74.1	120
Kentucky	4	2.1	20	10.6	119	63.3	45	23.9	188
Tennessee	14	1.9	101	14.0	254	35.2	353	49.0	722
Alabama	22	2.9	144	19.1	240	31.8	348	46.2	754
Mississippi	34	2.8	259	21.5	216	17.9	697	57.8	1,206
Arkansas	8	2.3	76	21.5	72	20.4	197	55.8	353
Louisiana	187	4.2	965	21.5	220	4.9	3,113	69.4	4,485
Oklahoma	4	3.6	11	10.0	20	18.2	75	68.2	110
Texas	49	3.4	168	11.5	85	5.8	1,158	79.3	1,460
California	34	3.5	97	9.9	4	.4	840	86.2	975
United States	581	3.1	3,332	17.7	2,102	11.1	12,850	68.1	18,865

Appendix Table 13. Season average price received by farmers in dollars per hundredweight, by state, 1950-1959

State	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
New Jersey	2.96	6.11	7.05	4.87	4.11	3.89	4.62	4.35	3.75	3.12
Indiana	3.33	4.67	5.24	5.04	4.36	---	---	---	---	---
Illinois	2.69	5.13	5.76	5.20	4.71	---	---	---	---	---
Iowa	3.75	4.56	5.51	5.04	5.05	---	---	---	---	---
Missouri	4.02	5.00	5.69	4.93	4.91	4.18	4.34	3.54	3.88	3.99
Kansas	3.89	5.11	6.44	4.85	4.55	3.80	3.75	4.98	4.34	3.68
Delaware	3.42	4.31	5.49	3.60	2.98	---	---	---	---	---
Maryland	3.18	4.07	4.93	3.75	2.85	2.51	3.91	3.00	3.12	3.37
Virginia	3.04	4.38	4.98	3.55	3.05	2.36	3.06	2.44	2.16	1.98
North Carolina	3.56	5.71	6.24	4.56	5.04	4.26	4.54	4.43	4.67	3.76
South Carolina	3.22	5.42	6.38	4.80	5.18	3.86	4.48	4.15	4.71	4.17
Georgia	3.56	6.40	7.44	5.40	5.89	4.39	4.91	5.05	5.00	4.73
Florida	4.24	5.18	7.47	6.49	6.15	6.10	5.61	5.97	5.92	5.30
Kentucky	3.80	4.89	6.02	5.13	4.67	3.64	3.59	3.71	4.12	4.47
Tennessee	3.45	5.67	6.38	5.55	4.96	3.43	4.21	4.35	4.49	3.78
Alabama	3.89	5.13	6.16	5.31	5.27	4.30	4.32	4.60	4.76	4.23
Mississippi	3.75	6.33	7.95	5.93	5.80	3.79	4.60	4.72	4.79	4.20
Arkansas	3.78	5.38	7.36	5.75	5.96	3.90	4.71	4.79	4.69	4.25
Louisiana	1.78	5.16	5.07	3.44	3.25	1.81	2.58	3.27	2.22	1.55
Oklahoma	3.85	5.80	7.45	4.96	5.38	4.09	5.42	5.18	4.29	4.19
Texas	3.20	5.96	7.87	4.84	5.73	3.34	5.63	4.96	4.55	3.43
California	5.04	8.55	7.53	7.91	7.31	7.58	7.34	7.81	7.50	7.37
United States	2.99	5.55	5.99	4.44	4.20	3.27	4.01	4.18	3.76	3.25

Appendix Table 14. Value of production of sweet potatoes, by state, 1950-1959

State	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
					(1,000 dollars)					
New Jersey	4,579	7,784	8,093	6,574	6,568	5,423	7,022	5,594	5,231	3,931
Indiana	220	205	157	71	174	---	---	---	---	---
Illinois	234	369	317	172	259	---	---	---	---	---
Iowa	195	301	331	277	167	---	---	---	---	---
Missouri	832	840	700	483	462	460	564	396	462	495
Kansas	335	240	148	107	191	236	146	383	417	353
Delaware	212	250	225	151	167	---	---	---	---	---
Maryland	1,647	1,791	2,095	2,655	1,465	1,298	1,724	1,650	1,938	1,914
Virginia	3,502	4,730	5,712	5,094	4,627	3,625	3,938	4,185	3,553	4,000
North Carolina	13,243	11,620	14,227	12,586	11,778	10,224	10,787	12,094	10,858	9,325
South Carolina	8,404	7,133	7,299	6,480	4,330	4,883	3,960	3,880	3,245	3,090
Georgia	7,832	5,760	6,785	5,940	3,711	5,707	5,568	5,323	5,025	4,995
Florida	1,068	953	1,180	1,363	947	1,074	707	716	556	636
Kentucky	1,357	1,423	1,662	1,195	1,331	1,354	890	868	667	840
Tennessee	3,353	3,181	4,058	2,869	2,976	3,217	2,640	2,506	2,200	2,729
Alabama	6,808	3,878	3,770	3,701	2,956	4,025	3,024	3,606	3,665	3,189
Mississippi	7,020	6,014	6,471	5,218	4,976	5,492	4,600	5,919	4,915	5,065
Arkansas	1,954	1,544	1,825	1,213	1,335	1,622	1,201	1,614	1,360	1,500
Louisiana	10,666	20,434	22,237	17,138	15,970	10,603	12,578	13,047	9,910	6,952
Oklahoma	886	713	417	546	527	654	618	559	506	461
Texas	6,918	4,506	5,950	6,828	5,157	6,393	3,744	6,126	5,460	5,008
California	4,324	5,386	5,346	6,178	6,228	6,102	7,046	7,498	7,965	7,186
United States	85,589	89,055	00,005	86,835	76,302	72,392	70,757	75,964	67,933	62,253

Appendix Table 15. Value of sales of sweet potatoes, by state, 1950-1959

State	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
					(1,000 dollars)					
New Jersey	3,833	6,788	6,994	5,766	5,577	4,532	6,232	4,615	4,552	3,164
Indiana	123	117	84	10	83	---	---	---	---	---
Illinois	121	195	161	57	137	---	---	---	---	---
Iowa	154	246	264	227	131	---	---	---	---	---
Missouri	387	340	296	217	211	227	321	319	264	299
Kansas	265	189	103	73	146	198	120	334	365	313
Delaware	164	190	170	223	122	---	---	---	---	---
Maryland	1,355	1,522	1,711	2,250	1,194	1,072	1,408	1,401	1,688	1,688
Virginia	2,335	3,219	3,800	3,653	3,434	2,740	3,103	3,514	3,013	3,344
North Carolina	4,970	3,632	4,930	4,879	4,249	4,064	5,534	5,825	5,875	5,486
South Carolina	3,159	2,271	1,971	2,251	989	2,015	1,689	1,689	1,366	1,355
Georgia	1,776	1,568	2,306	2,155	1,143	2,950	2,961	2,894	3,290	3,098
Florida	479	565	710	824	541	671	415	442	367	472
Kentucky	182	161	205	113	173	335	212	193	144	201
Tennessee	963	714	1,142	572	699	1,173	766	922	691	1,334
Alabama	1,307	549	671	908	764	1,036	838	1,113	1,580	1,472
Mississippi	1,530	1,412	1,526	1,423	1,032	2,191	1,684	2,558	2,409	2,927
Arkansas	412	382	486	247	292	589	429	776	643	857
Louisiana	6,657	14,567	17,050	12,367	11,047	6,999	9,309	8,610	7,433	4,825
Oklahoma	450	412	216	303	301	442	396	363	339	314
Texas	4,394	2,241	3,416	4,601	2,934	4,526	2,269	4,553	4,140	3,972
California	3,629	4,608	4,526	5,236	5,314	5,192	6,048	6,428	6,862	6,191
United States	38,636	45,888	52,738	48,314	40,513	40,947	43,734	46,449	45,021	41,816

Appendix Table 16. Quantity of sweet potatoes processed and per capita consumption of canned and fresh sweet potatoes, United States, 1940-1960

Year	Quantity processed		Per capita consumption of sweet potatoes	
	Canned a/	Dehydrated a/	Canned b/	Fresh c/
	(1,000 cwt.)		(lbs.)	
1940	---	---	.2	16.2
1941	631	---	.3	18.4
1942	292	350	.2	20.4
1943	386	507	.3	21.4
1944	534	959	.3	19.7
1945	976	1,050	.3	18.3
1946	1,324	140	.7	17.2
1947	536	---	.5	14.5
1948	577	---	.3	11.5
1949	998	---	.5	11.7
1950	1,350	---	.7	12.1
1951	1,031	---	.4	8.1
1952	1,616	---	.8	7.3
1953	1,552	---	.7	8.0
1954	1,289	---	.6	8.0
1955	1,612	---	.8	8.4
1956	1,606	---	.8	7.6
1957	1,698	---	.8	7.2
1958	2,247	---	1.1	6.6
1959	2,324	---	1.2	7.3
1960	1,820	---	.9	6.2

a/ Farm weight basis, calendar years.
b/ Net canned weight.
c/ Primary distribution weight.

Data for Appendix Tables 7 through 16 were obtained from the following sources: *Agricultural Statistics*, 1960, U. S. Department of Agriculture, Washington; *Crop Production*, 1950-1960 issues, U. S. Department of Agriculture, Washington; *North Carolina Agricultural Statistics*, 1950-1960 issues, Federal-State Crop Reporting Service, Raleigh; *Potatoes and Sweet Potatoes Revised Estimates, by States, 1949-1955 and 1954-1959*, U. S. Department of Agriculture, Statistical Bulletin Numbers 190 and 291, Washington; *Statistical Abstract*, 1959-1960 issues, Bureau of Census, U. S. Department of Commerce, Washington; *Sweet Potatoes, Estimates in Hundredweight, by States, 1868-1953*, U. S. Department of Agriculture, Statistical Bulletin No. 237, Washington; Supplements for 1956 and 1960 to *Consumption of Food in the United States*, U. S. Department of Agriculture, Washington.

Agricultural Experiment Station

North Carolina State College

Raleigh, N. C.

R. L. Lovvorn, Director of Research

Bulletins of this station will be sent free to all citizens who request them.

A. E. INFORMATION SERIES NO. 93
DEPARTMENT OF AGRICULTURAL ECONOMICS
NORTH CAROLINA STATE COLLEGE
RALEIGH, NORTH CAROLINA
JUNE, 1962

PLANNING DATA FOR THE SWEET POTATO INDUSTRY

2. Costs and Returns for a Model Canning Plant

633.4/N92
[illegible]
V.[illegible]

PLANNING DATA FOR THE SWEET POTATO INDUSTRY

2. Costs and Returns for a Model Canning Plant

Leigh H. Hammond

Richard A. King

A. E. Information Series No. 93
Department of Agricultural Economics
North Carolina State College
Raleigh, North Carolina
in Cooperation with the
Marketing Economics Division
Economic Research Service
United States Department of Agriculture

June, 1962

PREFACE

This publication is a contribution to the regional program of vegetable marketing research being conducted in the southern region under SM-8, Evaluation of Alternative Vegetable Marketing Organizations and Handling Methods. Other agencies cooperating in this research are the agricultural experiment stations in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Puerto Rico, South Carolina, Tennessee, Texas and Virginia and the Marketing Economics Division of the United States Department of Agriculture.

The research reported here was conducted cooperatively by the Horticultural Crops Section, Marketing Economics Division, USDA, and the Department of Agricultural Economics, N. C. State College. The first report in this series on Planning Data for the Sweet Potato Industry is entitled "Prices, Production and Assembly Costs" by Gene A. Mathia and Richard A. King.

* * * * * * * * * *

TABLE OF CONTENTS

Page

SUMMARY.. 3

INTRODUCTION... 5

PROCEDURE.. 6

THE CANNING PROCESS...................................... 7

VARIABLE INPUTS USED..................................... 10

RETURNS OVER VARIABLE INPUT COSTS......................... 15

GENERAL COSTS.. 18

INITIAL COST OF DURABLE INPUTS........................... 19

PROFITABILITY OF INVESTMENT: DEPRECIATION METHOD....... 21

PROFITABILITY OF INVESTMENT: CAPITALIZATION METHOD..... 25

FACTORS AFFECTING PROFITS................................ 31

CONCLUSIONS.. 37

APPENDIX... 38

LIST OF REFERENCES....................................... 49

SUMMARY

This is an analysis of the economic feasibility of establishing new sweet potato processing plants with an hourly capacity of 10,000 pounds of raw potatoes. Plants designed for each of six different lengths of season, from 600 to 1600 hours, have been studied. The effects of less-than-capacity operation, level of trim and peel loss, changes in input prices and price of the final product have been examined. A 10,000-pound per hour plant operating at capacity for 800 or more hours per season with 40 percent trim and peel loss would break even under recent cost-price relationships. This operation is used for comparisons in this summary.

At base prices and costs, total costs average $3.86 per case of canned sweet potatoes. This is roughly equal to the average f.o.b. price of canned sweet potatoes in the Virginia-Maryland area for the period 1955-60. Plants designed for 1600-hour seasons would operate for twenty cents per case less and 600-hour season plants for thirteen cents per case more than the 800-hour plant.

Operating with less than 10,000 pounds of raw product hourly increases cost per case. At 75 percent of capacity, cost per case increases from $3.86 to $4.21. At 50 percent of capacity, cost per case increases to $4.77 per case.

If plants experience trim and peel loss greater than 40 percent, the result is higher costs per case. With 50 percent trim and peel loss, costs in the 800-hour plant increase 37 cents to $4.23 per case. If it were possible to operate with 30 percent trim and peel loss, costs would fall 24 cents to $3.62 per case.

A 10 percent increase in the cost of raw potatoes from $2.00 to $2.20 per hundredweight increases the cost of canned potatoes by 7.7 cents per case. A 10 percent increase in the wage rate (10.8 cents per hour) increases the cost of canned potatoes 4.5 cents per case. A 10 percent increase in the cost of containers increases the cost per case 13.1 cents when the plant is operated at capacity.

Changes in price of the finished product have an important effect on profitability of a canning operation. A 5 percent decrease (20 cents per case) would bring finished product price down to the $3.66 per case cost of operating the 1600-hour plant at base costs used in this study.

PLANNING DATA FOR THE SWEET POTATO INDUSTRY

2 Costs and Returns for a Model Canning Plant

Leigh H. Hammond* and Richard A. King**

INTRODUCTION

There is general interest in possible methods of raising farm incomes and increasing employment opportunities in rural areas of the South. Increased processing of farm products offers one such possibility.

This report describes the investment in buildings and equipment necessary to can sweet potatoes in a specialized sweet potato plant.[1] It provides a basis for projecting the expenses and revenue that might be expected. The supply of raw products needed to run a plant at profitable levels is described. The influences of length of operating season, price paid for the raw product, price received for the finished product, wage rate and less-than-capacity operation on profitability of such an investment are shown.

The decision to invest in a new business should rest on reliable information about both the cost of producing a particular item and the revenue expected from its sale.

Two types of resources are used in canning sweet potatoes: those making their complete contribution during a single production period and those contributing to the process over a number of production periods. In sweet potato canning the first group, called variable inputs, includes labor, raw product, sugar, lye, water, power, cans, cases, and labels. The second group, called durable inputs, includes various items of equipment and buildings.

---

* Director, Division of Statistics and Economics, National Canners Association, formerly Agricultural Economist, Marketing Economics Division, U. S. Department of Agriculture.

** M. G. Mann Professor, Department of Agricultural Economics, North Carolina State College.

[1] Basic data used in this report were drawn from a study by Leigh H. Hammond entitled, "An Evaluation of the Opportunity for Investment in Sweet Potato Canning Plants in North Carolina," submitted to the Graduate Faculty of North Carolina State College in partial fulfillment of the requirements for the Degree of Doctor of Philosophy, Raleigh, North Carolina, 1961.

Durable inputs are the focal point of an investment decision since it is for these items that large sums of money must be committed for relatively long periods of time. Several production periods are usually required before investment in durable inputs is recovered. However, emphasis on funds necessary for purchasing durable inputs should not detract from the importance of the availability of short-term operating funds as a strategic consideration in an investment decision.

PROCEDURE

Two approaches might be used in estimating the cost of canning sweet potatoes. One method is based on visits to existing plants to determine their cost per unit of output for the most recent operating season. The second method supplements knowledge of existing plants with information from equipment companies and processing specialists to determine the necessary initial investment and the variable input requirements as a basis of cost estimation for a new plant.

The method of canvassing existing plants has the disadvantage of concealing the effects of less-than-capacity operation and differences in prices on the single cost-per-unit figure quoted by the plant manager. If estimates are obtained over a range of plant sizes, any attempt to estimate economies to scale will result in an upward cost bias. The second approach is commonly referred to as the economic-engineering (3) approach to cost estimation. It is generally regarded as giving more reliable indications of the true cost picture that a new plant would face.

Since this study was focused on the feasibility of establishing new plants, the economic-engineering approach gave promise of more reliable results and was used in estimating the cost of canning sweet potatoes.

For the model plant described in detail in this report, an input of 10,000 pounds of raw product per hour of plant operation was assumed as full capacity. A few brief comparisons are made with larger plants. The sweet potato canning season begins in September and usually ends in December or early January. A range of 600 to 1600 hours operation within this time period was studied. Typical operating schedules are shown in Table 1.

In selecting techniques for the model plant, existing plants were surveyed in both North Carolina and Louisiana; food processing research specialists were consulted, and food machinery engineers from several manufacturers provided valuable advice. Based on this information, a model plant has been specified which includes economical techniques at the various operating stages and also closely approaches the type of plant a new investor would consider building.

Table 1. Typical operating schedules for sweet potato canning plants

Shift	Length of season (hours)					
	600	800	1000	1200	1400	1600
First shift:						
Hours/week	40	40	40	40	48	50
Weeks/year	15	15	15	15	15	16
Second shift:						
Hours/week	--	40	40	40	45	50
Weeks/year	--	5	10	15	15	16

Building costs were estimated with the help of building engineers. Equipment companies provided technical information and the installed cost for essential machinery.

Operating costs were estimated from variable input data gathered from existing plants, food processing specialists, and suppliers of the variable input items. A time and production (5) study 1/ in Louisiana canning plants provided labor production standards, or work loads, for each job in the canning operation. These standards were used to compute crew requirements and labor costs. Concurrently with the time and production study, data on variable inputs were collected to supplement and verify information obtained from other sources. Plant records and interviews with plant managers gave the information essential for estimating general operating expenses including general office and plant supplies, telephone, salaries, taxes, insurance and maintenance. More specific details will be given in a subsequent section on the procedure for estimating costs of individual inputs.

THE CANNING PROCESS

An outline and description of major operations in a sweet potato canning plant are essential to a clear understanding and specification of input-output coefficients.

Selection of techniques was based on what would probably be included in plants planned for construction in the near future. The model plant does not necessarily duplicate techniques of operation found in any existing plant. However, all techniques which were included were observed at some stages in various existing plants.

Raw Product Receipt. Growers usually deliver sweet potatoes to a canning plant in 50-pound field crates. Following

---

1/ The technique of work sampling was used effectively in this portion of the study.

the purchase transaction, field crates are dumped into bulk pallet boxes or bins which contain approximately 1,350 pounds (27 field crates). A fork lift truck transfers the bin to temporary storage.

Dumping. When the plant is in operation, a fork lift truck removes bins from temporary storage and places them on a bin dump mechanism which inverts the bin, dumping the sweet potatoes onto an elevator leading to the initial washing.

Washing. A rotary cage washer removes dirt and other foreign material.

Preheating. Preheating sweet potatoes in water at a temperature of 140 degrees to 150 degrees F for 6 to 10 minutes before peeling reduces action of enzymes near the surface resulting in less discoloration of the product between peeling and closing operations. The preheating also tends to increase efficiency of the peeling operation.

Peeling. The sweet potatoes drop into a hot caustic soda solution (lye) which softens the skin.

Washing. Sweet potatoes move from the lye peeler into a rotary washer equipped with high pressure water sprays. These high pressure sprays, in conjunction with abrasive action of the rotary drum, loosen the skins and wash them away.

Trimming. The freshly peeled sweet potatoes move to an open inspection and trim belt where workers pick up each potato and trim away the stringy ends and other undesirable portions. The product suitable for canning is placed on a belt leading to subsequent operations. A major portion of labor requirements of the production line is consumed in the trimming operation.

Sizing. A rotary drum with variable size openings separates the raw product into three or four size categories.

Slicing. Large potatoes move through a series of cutting machines which first halve, then quarter the potatoes, and finally slice the quarters into small pieces.

Filling. The filling operation consists of the raw product moving onto a circular hand-pack filler with a series of openings around its outer edge through which potatoes are raked into cans passing below as the circular top rotates.

Syruping. Most canned sweet potatoes are packed in a syrup medium of sugar and water heated to a temperature just below boiling. The cans move from the filler to an automatic syrup filling machine. Each can moves onto a lifter pad which raises the can to a valve, sealing the lip of the container against the rubber valve and opening the valve, all in one operation. As the cans continue their travel, they are filled with syrup after which the lifter pad lowers to discharge height and the cans move onto the discharge conveyor.

Exhausting. On completion of filling cans with both raw product and syrup, they move through a steam exhaust box to heat the contents to an internal temperature of 160 degrees to 170 degrees F.

Closing. A seamer or sealing machine places a lid on each can and applies pressure to seal the can. An attendant removes the sealed cans from a discharge lip and places them in a retort crate for transfer to cooking retorts.

Retorts. High pressure steam retorts are used to cook the canned product for varying periods of time, depending on can size, syrup content, and the average temperature of the contents when placed in the retorts. Overhead hoists are used to transfer and lower retort crates into cooking retorts. On removal from the retorts, cans are placed in a cooling canal located between the rows of retorts.

Casing. The retort crates are removed from the cooling canal and moved to a crate dump mechanism which inverts the crate and empties its contents onto an unscrambler which aligns the cans for entrance to a labeling machine. If labels are to be applied immediately, the machine applies a label to each can and discharges it into a casing machine which places the right number of cans in each case. The filled case moves through a compression sealer in which glue is spread on the top and bottom flaps, and pressure is applied to seal the case. When the cases are discharged from the case sealer, a laborer stacks them on a pallet for removal by fork lift truck to storage.

Occasionally cans are cased without labels to permit flexibility in selling to buyers who specify, as a condition of purchase, that their labels must be on the cans. When this is the case, cans pass through the labeling machine without picking up a label and are cased with the tops and bottoms of the cases interlocked by hand and then stacked on pallets for transfer to storage.

When sales of unlabeled cans are made, pallets are removed from storage, cases opened, and cans placed on the labeling machine. Then labeling, casing, and case sealing proceed as described above.

Warehousing. This operation involves transfer of cased goods to storage and removal from storage as shipments are scheduled. Since sales and shipment activities spread over the entire year, a small warehouse crew is maintained for labeling and shipping activities.

VARIABLE INPUTS USED

The capacity of this plant is specified in terms of the quantity of raw product dumped per hour of operation. Coefficients showing inputs per hour of plant operation are needed for estimating costs. Requirements for certain factors are related to the quantity of raw product dumped while others are related to the quantity of product suitable for canning and the distribution of pack between can sizes. Therefore, assumptions about product yield and distribution of pack must be made in estimating costs.

Assumed Yield. The yield of product suitable for canning was observed to range from 40 to 70 percent in existing plants which were studied in both North Carolina and Louisiana. Stated another way, trim and peel loss ranged from 30 to 60 percent. The average trim and peel loss was about 42 percent of total pounds dumped. In this study costs were estimated for 30, 40, and 50 percent trim and peel loss rates.

Size of Can Packed. Existing plants use a combination of several different size cans. Variation in size of sweet potatoes and limited range of alternatives to offer buyers are important considerations which encourage use of more than one can size. However, nearly 90 percent of the total United States pack of sweet potatoes is in four can sizes (Table 2). It is assumed that total pack is allocated among the four most commonly used can sizes in the same relative distribution as the total United States pack in 1958 and 1959.

Table 2. Sweet potato pack by size of container, United States average, 1958-1959 season

Can size	Quantity packed	
	(thousand cases)	(percent)
3 squat	2,206	35.9
2 1/2	1,290	21.0
303	1,238	20.1
10	798	13.0
8 oz.	279	4.5
3 cyl.	222	3.6
2	88	1.4
Misc.	30	0.5
Total pack	6,151	100.0

Source: The Almanac of the Canning, Freezing, Preserving Industries, 1960 edition.

Each can size holds a different quantity of raw product as shown in Table 3. The equivalent distribution of cases packed per 1,000 pounds of raw product received is shown in Table 3 for plants experiencing 40 percent trim and peel loss. Pack out can be adjusted proportionally for other levels of trim and peel loss.

Raw Product. The rate of plant operation determines input of raw product per unit of time. Assuming capacity operation of 10,000 pounds of sweet potatoes per hour of operation, raw product required will vary directly with length of season. Cost of raw product actually canned is a function of price paid to growers and percent trim and peel loss. A detailed elaboration on raw product costs is presented later.

Direct Labor. Input of direct labor varies with the rate of plant operation, yield of raw product suitable for canning and allocation of pack among can sizes. A few jobs, however, are machine paced and vary discontinuously with increases in plant capacity.

A time and production study in six canning plants in Louisiana provided estimates of unit time requirements for those jobs which are closely dependent on volume of output. The six plants were selected to give a range of up-to-date techniques for performing each job. Approximately 60 percent of the total Louisiana pack and 27 percent of the total United States pack were canned in the six plants in which the work sampling study was conducted.

The unit time requirements from the work sampling study, with a standard allowance of 15 percent for unavoidable delay, were converted to work standards 1/ for use in estimating crew requirements for various operating situations (Appendix Table 2). For jobs not particularly sensitive to volume changes, crew requirements were estimated from interviews with plant managers. Their jobs involve things like cleaning up, attending to lye tank, washing and peeling, etc.

Crew requirements and direct labor costs are presented in Table 4 for this 10,000-pound per hour plant where 40 percent trim and peel loss is assumed. Appendix Table 3 presents comparable data where 30 and 50 percent trim and peel loss are assumed.

Sugar. Syrup mixtures range from 20 degrees Brix to 50 degrees Brix concentration, with 30 degrees Brix as the most common concentration. The Brix measure is merely an indication of the quantity of sugar in 100 pounds of syrup. Thus, a 30 degree Brix syrup has 30 pounds sugar and 70 pounds water per 100 pounds.

1/ A work standard is defined as the quantity of material or product (specified in appropriate units) a person of average ability can handle each hour of operation.

Table 3. Distribution of raw product and finished product assumed for computing cost and revenue in model sweet potato canning plant

Can size	Net weight of raw product per case a/	Cases packed per 1,000 pounds raw product b/	Assumed distribution of raw product c/	Equivalent distribution of cases packed per 1,000 lbs. raw product d/	
	(pounds)	(no. cases)	(percent)	(no. cases)	(percent)
303	17.25	34.8	18	6.3	24
3 squat	22.50	26.7	37	9.9	38
2 1/2	28.50	21.1	28	5.9	23
10	27.00	22.2	17	3.8	15
Total	-	-	100	25.9	100

---

a/ See Appendix Table 1 for details.
b/ Assuming 40 percent trim and peel loss, divide 600 by values in column 1.
c/ Based on 1958-59 distribution of national pack.
d/ Column 2 multiplied by column 3.

Table 4. Crew requirements and direct labor cost per hour of plant operation for a 10,000-pound per hour sweet potato canning plant a/

Job	Workers	Wage rate	Direct labor cost
	(number)	(dol/hour)	(dol./hour)
Receive raw product	1	1.73	1.73
Operate dump	1	1.05	1.05
Tend lye tank	1	1.73	1.73
Wash and peel attendant	1	1.05	1.05
Trim	57	1.05	59.85
Attend slicer	2	1.05	2.10
Fill: 2 1/2	3	1.05	3.15
303	3	1.05	3.15
3 squat	4	1.05	4.20
10	2	1.05	2.10
Mix syrup	1	1.05	1.05
Closing machine: 2 1/2	1	1.05	1.05
303	1	1.05	1.05
3 squat	2	1.05	2.10
10	1	1.05	1.05
Empty can supply: 2 1/2	1	1.05	1.05
303	1	1.05	1.05
3 squat	1	1.05	1.05
10	1	1.05	1.05
Move to retort	1	1.05	1.05
Operate retort	3	1.26	3.78
Move from retort	1	1.05	1.05
Crate dump	1	1.05	1.05
Operate label machine	1	1.05	1.05
Form cases	2	1.05	2.10
Casing: 2 1/2 and 303	1	1.05	1.05
3 squat and 10	1	1.05	1.05
Stack cases	1	1.05	1.05
Operate fork lift			
Raw product receipt and dump	1	1.05	1.05
Cannery to warehouse	1	1.05	1.05
Warehouse	2	1.05	2.10
Attend boiler	1	1.30	1.30
Clean-up	3	1.05	3.15
Supervisor			
Trim	1	1.58	1.58
Closing	1	1.58	1.58
Total	107	----	115.65

a/ Assuming 40 percent trim and peel loss and the following distribution of pack out: No. 2 1/2 - 23 percent; No. 303 - 24 percent; No. 3 squat - 38 percent; and No. 10 - 15 percent. Wage rates include a 5 percent allowance for fringe benefits.

Sugar requirements are computed on the basis of output of each can size. The quantity of syrup in each can size determines the quantity of sugar required (Appendix Table 4).

Lye. Two forms of caustic soda--solid and liquid--are available for lye peeling operations. The break-even point between solid and liquid is at a fairly low volume. Therefore, for situations analyzed in this report, use of liquid caustic soda was assumed. Caustic soda (technically "sodium hydroxide," NaOH) contains, if pure sodium hydroxide, 77.48 percent pure sodium oxide (Na_2O). The solid form of commercial caustic soda is 96.09 percent pure sodium hydroxide and, therefore, contains 76 percent sodium oxide. Commercial caustic soda is sold in terms of equivalent sodium oxide content, hence "76 percent caustic soda."

Liquid caustic is sold on the basis of equivalent units of 76 percent sodium oxide to permit comparisons of liquid and solid. Two concentrations--50 and 73 percent--of liquid are available. The 50 percent liquid is more commonly used in lye peeling of sweet potatoes since the 73 percent liquid requires special handling and storage facilities.

Input requirements are specified in pounds of solid caustic per 1,000 pounds of sweet potatoes dumped. Approximately 27.6 pounds of solid caustic are required for each 1,000 pounds of raw product (1, 6). No reliable relationship could be established between caustic requirements and percent trim and peel loss (6). One gallon of 50 percent liquid caustic is equivalent to 6.5 pounds of solid. Therefore, 4.25 gallons per 1,000 pounds of raw product is the input coefficient for 50 percent caustic soda in sweet potato peeling operations.

Cans. The net weight of potatoes in each can size is the strategic information needed for computing input requirements for cans. The net weight enables computation of can needs for any assumed yield of product suitable for canning and pack distribution (Appendix Table 5). A 5 percent allowance was included for bent and damaged cans.

Labels. Input of labels parallels that of cans except that a 15 percent allowance is made for damaged labels because of a high rate of loss in the labeling machine.

Cases. Output of different size cans and the number of cans per case determine case requirements as shown earlier in Table 3.

Power. Electrical power consumption is related directly to the total horsepower necessary to operate the canning line. Engineering estimates suggest that one motor horsepower consumes one kilowatt of electrical power per hour of operation. The motor horsepower shown in Appendix Table 2 is aggregated and a 10 percent allowance is added for lighting to estimate total power requirements per hour of operation.

Water. Specific operations and machine use of water such as for washing, peeling and steam generation determine quantities needed per hour (Appendix Table 6). These estimates were provided by equipment manufacturers.

Fuel. Two operations require fuel oil: the operation of fork lift trucks and the generation of steam. Fork lift trucks consume an average of 1 gallon of fuel per hour. Boilers consume fuel oil at a rate of 1/3 gallon per hour per boiler horsepower. Thus, a 150 rated horsepower boiler requires 50 gallons of fuel oil per hour of operation.

Variable Maintenance. A portion of machinery and equipment repairs is related to the amount of use per year. The variable repair or maintenance costs were computed as 0.5 percent of equipment replacement value (initial investment cost) per 100 hours of operation (3).

Total Variable Operating Costs. The application of appropriate prices to the input requirements per hour of operation gives estimated variable costs per hour. The prices for variable inputs were obtained from various suppliers of these items and are listed in column 1 of Table 5. Inputs and variable costs per hour for a plant with 40 percent trim and peel loss are presented in columns 2 and 3. Using the input requirements and prices as outlined in this section, total variable costs of canning are $787.97 per hour of operation at capacity of 10,000 pounds raw product. Similar estimates of variable input quantities and costs for plants having 30 and 50 percent trim and peel loss are presented in Appendix Table 7.

RETURNS OVER VARIABLE INPUT COSTS

Gross sales can be estimated for plants operating varying lengths of season if the distribution of pack by size of can and net plant prices for each size are known. The distribution used in this study is in Table 3.

The value of canned sweet potatoes assumed here was based on f.o.b. quotations for the Maryland-Virginia area. The volume of shipments from North Carolina has been insufficient to warrant inclusion in published price quotations. However, the Maryland-Virginia data should provide a close approximation to expected prices for sweet potatoes canned in North Carolina.

Prices received in Maryland and Virginia for canned sweet potatoes from 1955 to 1960 are presented in Appendix Table 8. These prices were averaged over the 1955-1960 period to provide estimates of prices for different can sizes listed below. The weighted average price used in this analysis is $3.86 per case.

Table 5. Variable input requirements and variable costs for a model sweet potato canning plant having a capacity of 10,000 pounds of raw product per hour of operation a/

Item	Unit	Price (dol./unit)	Quantity (unit/hr.)	Cost (dol/hr.)
Raw product	cwt.	2.00	100.00	200.00
Direct labor	man-hrs.	1.08 b/	107.00	115.65
Sugar (30° Brix syrup)	cwt.	10.00	9.81	98.10
Lye	gallons	.25	42.50	10.63
Cans c/ - 2 1/2	M	51.00	1.487	75.48
303	M	33.50	1.577	52.83
3 squat	M	51.00	2.478	126.84
10	M	125.22	.238	29.80
Labels d/-2 1/2	M	3.80	1.628	6.19
303	M	2.80	1.727	4.84
3 squat	M	3.15	2.724	8.58
10	M	8.65	.261	2.26
Cases - 2 1/2	M	133.00	.059	7.85
303	M	107.00	.063	6.74
3 squat	M	142.00	.099	14.06
10	M	131.00	.038	4.98
Power	kwh	.0134	63.000	.84
Water	M gal.	.15	19.3	2.90
Fuel	gallon	.155	54.0	8.37
Variable repairs e/				11.03
Total				787.97

a/ Assuming 40 percent trim and peel loss and the following distribution of raw product: No. 2 1/2 cans - 23 percent; No. 303 cans - 24 percent; No. 3 squat cans - 38 percent, and No. 10 cans - 15 percent.

b/ Wage rate varies by job, see Table 4.

c/ Allows 5 percent for damaged cans.

d/ Allows 15 percent for damaged labels.

e/ Computed on basis of 0.5 percent of equipment replacement cost per 100 hours operation.

Can size	Assumed distribution of pack out (percent)	Average price per case (dollars)
303	24	2.68
3 squat	38	4.10
2 1/2	23	4.50
10	15	4.16
Total	100	3.86

Total revenue at capacity operation varies directly with hours of operation. Estimates for 600 to 1600 hours are shown in Table 6. Total costs of variable inputs are also presented for the same lengths of season. Returns over variable costs range from 127 to 338.9 thousand dollars annually. The average cost of variable inputs amounts to $3.042 per case, leaving $.818 per case over variable costs with the assumed price of $3.86 per case.

Table 6. Returns per season and returns per case over variable input costs in a model sweet potato canning plant handling 10,000 pounds of raw product per hour with 40 percent trim and peel loss

Item	Description	Length of season (hours)					
		600	800	1000	1200	1400	1600
Cases packed:		(thousand cases)					
No. 2 1/2	59/hour	35.4	47.2	59.0	70.8	82.6	94.4
No. 303	63/hour	37.8	50.4	63.0	75.6	88.2	100.8
No. 3 squat	99/hour	59.4	79.2	99.0	118.8	138.6	158.4
No. 10	38/hour	22.8	30.4	38.0	45.6	53.2	60.8
Total		155.4	207.2	259.0	310.8	363.6	414.4
		(thousand dollars per year)					
Total revenue	$3.86/case	599.8	799.8	999.7	1199.7	1399.6	1599.6
Total variable input costs:		(thousand dollars per year)					
Raw product	$2/cwt.	120.0	160.0	200.0	240.0	280.0	320.0
Direct labor	Man-hours	69.4	92.5	115.6	138.8	161.9	185.0
Cans		171.0	228.0	285.0	341.9	398.9	455.9
Sugar & lye		65.2	87.0	108.7	130.5	152.2	174.0
Cases		20.2	26.9	33.6	40.4	47.1	53.8
Labels		13.1	17.5	21.9	26.2	30.6	35.0
Power, water and fuel		7.3	9.7	12.1	14.5	17.0	19.4
Variable repairs	0.5% cost/ 100 hours	6.6	8.8	11.0	13.2	15.4	17.6
Total variable inputs		472.8	630.4	787.9	945.5	1103.1	1260.7
Returns over variable costs		127.0	169.4	211.8	254.2	296.5	338.9
Average variable input costs:		(dollars per case)					
Raw product	$2/cwt.	.772	.772	.772	.772	.772	.772
Direct labor	Man-hours	.447	.446	.446	.447	.447	.447
Cans		1.100	1.100	1.100	1.100	1.100	1.100
Sugar & lye		.420	.420	.420	.420	.420	.420
Cases		.130	.130	.130	.130	.130	.130
Labels		.084	.084	.084	.084	.084	.084
Power, water and fuel		.047	.047	.047	.047	.047	.047
Variable repairs	0.5% cost/ 100 hours	.042	.042	.042	.042	.042	.042
Total average variable inputs		3.042	3.042	3.042	3.042	3.042	3.042
Returns over variable costs		.818	.818	.818	.818	.818	.818

GENERAL COSTS

In addition to variable costs, closely related to hourly operation, annual operating costs must be met. These general costs include salaries of management, property taxes, interest on short-term credit, insurance, office expenses, warehouse personnel, annual repairs to buildings and equipment, and sales expense. Accounting records and interviews with managers of existing plants provided the basis for estimating general expenses.

Salaries. Employees on an annual basis include a manager, assistant managers, secretarial and payroll personnel and laborers for warehousing and shipping activities. Table 7 presents estimated personnel requirements and costs for management, office and miscellaneous plant labor.

Table 7. Management and miscellaneous personnel salaries

Job	Personnel	Annual salaries
	(number)	(dollars)
Manager	1	$ 7,000
Assistant manager	2	10,000
Secretarial and payroll	2	4,800
Miscellaneous plant labor	10	21,000
Total salaries		$42,800

Office Expense. The expenses of conducting business, such as telephone, office supplies, and licenses, are related in part to volume of business. Information from existing operations indicates that approximately 2 percent of total sales is required for general office expense.

Sales Expense. Some canning plants sell through brokerage firms while others sell through their own salesmen. In either case, sales expense is approximately 6 percent of total sales.

Taxes. Property taxes must be paid on buildings and equipment. These tax rates average, in North Carolina, 1.0 percent of the initial cost of buildings and equipment.

Insurance. Fire insurance rates on buildings and contents of canning plants in North Carolina averaged $1.50 per $100 valuation or 1.5 percent of initial investment cost of buildings and equipment and average value of inventory.

Interest. The availability of short-term credit for operating capital is a very important consideration in a canning operation. When operating at capacity, this plant required $788 for each hour of operation for variable inputs alone as shown earlier in Table 5. Since production occurs in the four-month period from September through December and sales are spread over a 12-month period, credit needs are computed on the basis of the average amount of operating capital tied up in inventory for the year (Appendix Table 9). The relationship of short-term interest costs to length of season is shown in Table 8.

Annual Repairs. Costs of annual repairs were an estimated 1.5 percent of initial cost of building and equipment (3).

Total General Costs. General costs are related partially to length of season in that interest for short-term credit, sales cost, insurance, and office expense are dependent on quantity of output and sales. Table 9 summarizes the components of general costs for a plant operating at 10,000 pounds per hour with a range of 600 to 1600 hours operating season with 40 percent trim and peel loss assumed. Different assumptions about trim and peel loss are shown in Appendix Table 10.

Table 8. The relationship of length of operating season, average monthly inventory and short-term credit costs in 10,000-pound per hour sweet potato canning plant a/

Length of season (hours)	Average inventory b/ (dollars)	Interest on average inventory c/ (dollars)
600	157,600	9,500
800	210,100	12,600
1000	262,400	15,700
1200	315,200	18,900
1400	367,800	22,100
1600	420,300	25,200

a/ Assuming 40 percent trim and peel loss and the following distribution of pack: No. 2 1/2 cans - 23 percent; No. 303 cans - 24 percent; No. 3 squat cans - 38 percent; and No. 10 cans - 15 percent.

b/ Appendix Table 9.

c/ Interest rate for short-term credit assumed to be 6 percent per annum.

INITIAL COST OF DURABLE INPUTS

Entering the sweet potato canning business requires investment in buildings, equipment, and miscellaneous durable inputs. These costs are summarized in Table 10 for plants processing 10,000 pounds per hour with storage space ranging from 15 to 40 thousand square feet.

Table 9. General costs of plant operation associated with varying length of season in a 10,000-pound per hour model plant a/

Item	Description	Length of season (hours) 600	800	1000	1200	1400	1600
		(thousand dollars per year)					
General costs:							
Salaries	fixed/year	42.8	42.8	42.8	42.8	42.8	42.8
Office expense	2% of sales	12.0	16.0	20.0	24.0	28.0	32.0
Sales expense	6% of sales	35.9	47.9	59.9	71.9	83.9	95.8
Insurance	1.5% of bldgs., equip. & inventory	7.7	8.7	9.7	10.7	11.7	12.7
Taxes	1% of bldgs. & equipment	3.5	3.7	3.8	4.0	4.1	4.3
Interest	6%/yr. on ave. inventory	9.5	12.6	15.8	18.9	22.1	25.2
Annual repairs	1.5% of bldgs. & equipment	5.3	5.5	5.8	6.0	6.2	6.4
Total general costs		116.7	137.2	157.8	178.3	198.8	219.2

a/ Assuming 40 percent trim and peel loss.

Buildings. Space requirements can be categorized into canning plant area, storage area, office space, boiler house, and service area. Since a specialized plant operates only about four months per year while sales extend over a 12-month period, storage space is needed for approximately two-thirds of a season's production. Total building cost, therefore, varies with the length of season for which the plant is designed.

Costs were estimated for steel prefabricated type buildings, including 5-inch reinforced concrete floors, plumbing, heating, and electrical wiring. Space requirements and cost are given in Appendix Table 11.

Equipment. The installed cost of the equipment necessary for a rate of operation of 10,000 pounds/hour was provided by equipment companies who manufacture each item. The horsepower required, the number of pieces of equipment needed and total equipment cost are given in Appendix Table 12.

Miscellaneous Durable Inputs. Necessary durable items other than buildings and equipment include bins for handling the raw product and pallets for handling and storage of the finished product. Bin requirements were estimated so that each plant would have sufficient raw product on hand to operate 40 hours. Pallet requirements were estimated on the basis of each plant having a peak inventory of two-thirds of a season's output (Appendix Table 13).

Table 10. Initial cost of durable inputs for sweet potato canning plants processing 10,000 pounds per hour with storage capacity designed for 600 to 1600 hours per season a/

Item	Length of season (hours)					
	600	800	1000	1200	1400	1600
			(million pounds)			
Raw product used	6.0	8.0	10.0	12.0	14.0	16.0
			(thousand cases)			
Finished product packed b/	155.4	207.2	259.0	310.8	362.6	414.4
			(thousand square feet)			
Storage space needed c/	15	20	25	30	35	40
Initial cost of durable inputs			(thousand dollars)			
Building						
Office and plant	83.5	83.5	83.5	83.5	83.5	83.5
Storage area	37.5	50.0	62.5	75.0	87.5	100.0
Equipment	221.5	221.5	221.5	221.5	221.5	221.5
Bins and pallets	12.0	14.5	17.0	19.5	22.0	24.5
Total initial cost	354.5	369.5	384.5	399.5	414.5	429.5

---

a/ Plants differ only in amount of storage area and pallets required. All operate with 40 percent trim and peel loss.

b/ Distribution by size of can discussed in Table 3.

c/ Assumes peak storage requirement of two-thirds of annual output at 15 square feet per 100 cases.

PROFITABILITY OF INVESTMENT: DEPRECIATION METHOD

Two methods of computing returns will be presented. The first is a commonly used method of depreciating the initial cost of durable inputs over the expected life of each item. The second method is referred to as the capitalization method and entails the estimation of the present value of the expected flow of income from the plant over a specified time period. When compared with the present value of the cost of the plant, it provides a basis for deciding whether or not to build such a plant.

The annual depreciation on durable inputs for a plant operating 10,000 pounds per hour is given in Table 11. Increasing the length of season affects plant design and thus durable input costs only through larger storage area needed and added pallets for storing the additional inventory. Interest of 6 percent on one-half the initial investment is shown in Table 12. Durable costs per case, which include both depreciation and interest, decline from $.197 for a

Table 11. Annual depreciation of durable inputs for plants processing 10,000 pounds per hour with storage capacity designed for 600 to 1600 hours per season

Item a/	Rate	Length of season (hours)					
		600	800	1000	1200	1400	1600
	(percent)	(thousand dollars per year)					
Building:							
Office and plant	3.33	2.8	2.8	2.8	2.8	2.8	2.8
Storage area	3.33	1.2	1.7	2.1	2.5	2.9	3.3
Equipment	6.67	14.8	14.8	14.8	14.8	14.8	14.8
Bins and pallets	10.0	1.2	1.4	1.7	2.0	2.2	2.4
Depreciation per year		20.0	20.7	21.4	22.1	22.7	23.3
		(dollars per case)					
Building:							
Office and plant	3.33	.018	.014	.011	.009	.008	.007
Storage area	3.33	.008	.008	.008	.008	.008	.008
Equipment	6.67	.095	.071	.057	.048	.041	.036
Bins and pallets	10.0	.008	.007	.007	.006	.006	.006
Depreciation per case		.129	.100	.083	.071	.063	.056

a/ Initial cost of each item is presented in Table 10.

Table 12. Interest on initial investment in building, equipment, bins and pallets a/

Plant design	Cost per year	Cost per case
(hours per season)	(thousand dollars)	(dollars)
600	10.6	.068
800	11.1	.054
1000	11.5	.044
1200	12.0	.039
1400	12.4	.034
1600	12.9	.031

a/ Computed at 6 percent on one-half the initial investment given in Table 10.

plant operating 600 hours per season to $.110 at 1200 hours and to $.087 at 1600 hours per season (Table 13).

General costs per case also fall with plants designed for longer seasons. In the 600-hour plant, general costs average $.751 per case; at 1200 hours, $.574 per case; and at 1600 hours, $.529 per case.

Table 13. Total plant costs per case for a 10,000-pound per hour plant designed for varying lengths of season operating at capacity with 40 percent trim and peel loss

Length of season	Variable input costs a/	General costs b/	Depreciation and interest c/	Total costs
(hours)	(dollars per case)			
600	3.042	.751	.197	3.990
800	3.042	.663	.153	3.858
1000	3.042	.609	.127	3.778
1200	3.042	.574	.110	3.726
1400	3.042	.548	.097	3.687
1600	3.042	.529	.087	3.658

---

a/ See Table 6.

b/ Total annual general costs are given in Table 9. Average general costs are based on 259 cases per hour of operation.

c/ See Tables 11 and 12.

As described earlier, variable inputs average $3.042 per case for all plants operating with 40 percent trim and peel loss. When these three cost categories are added, a plant operating at 1600 hours per season operates at a cost of $.33 per case below that of a plant operating 600 hours per season (Table 13).

Trim and Peel Loss. An average price of $3.86 is not sufficient for profitable operation of a 10,000-pound per hour plant designed for a season of 800 hours or less. If trim and peel loss is reduced to 30 percent, the prospect is somewhat brighter. At 50 percent trim and peel loss, a price of $3.86 is not sufficient to cover variable input costs and general costs alone (Figure 1).

Less Than Capacity Operation. Data presented above refer to plants receiving 10,000 pounds per hour for varying lengths of season, the cost of processing being influenced through larger storage space needed as the processing period increases. A second variable of interest is the effect of operating at a lower rate than that for which the plants were designed. The effect is a substantial increase in costs per case when it is assumed that labor is available for full scale operation. The costs of cans, cases, labels, sugar and lye are regarded as varying proportionately with rate at which raw product is received. The cost per case for an 800-hour operation is shown in Table 14 at 75 percent and 50 percent of capacity when other costs are unchanged.

Detailed cost data are presented in Appendix Table 14, but the general effect of less-than-capacity operation is illustrated in Figure 2. Clearly, sweet potato processing

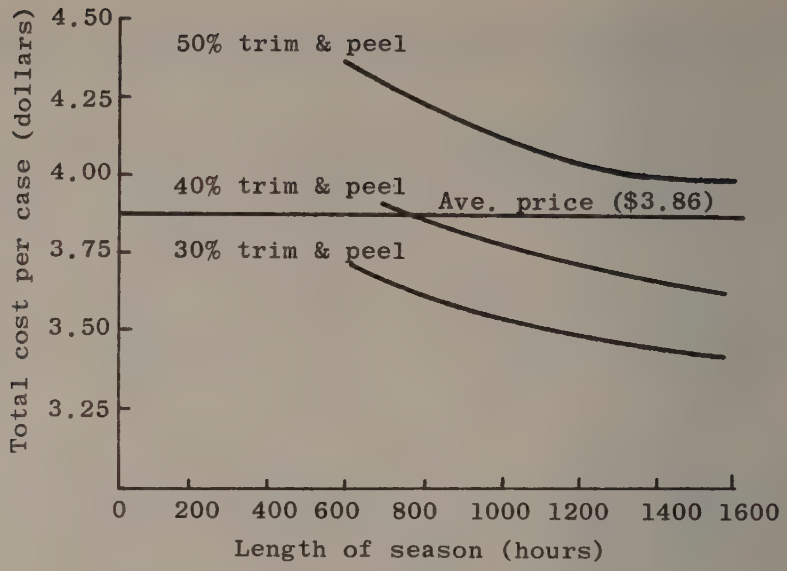


Figure 1. The relationship between length of season, trim and peel loss, and total cost per case of canning sweet potatoes in a 10,000-pound per hour plant

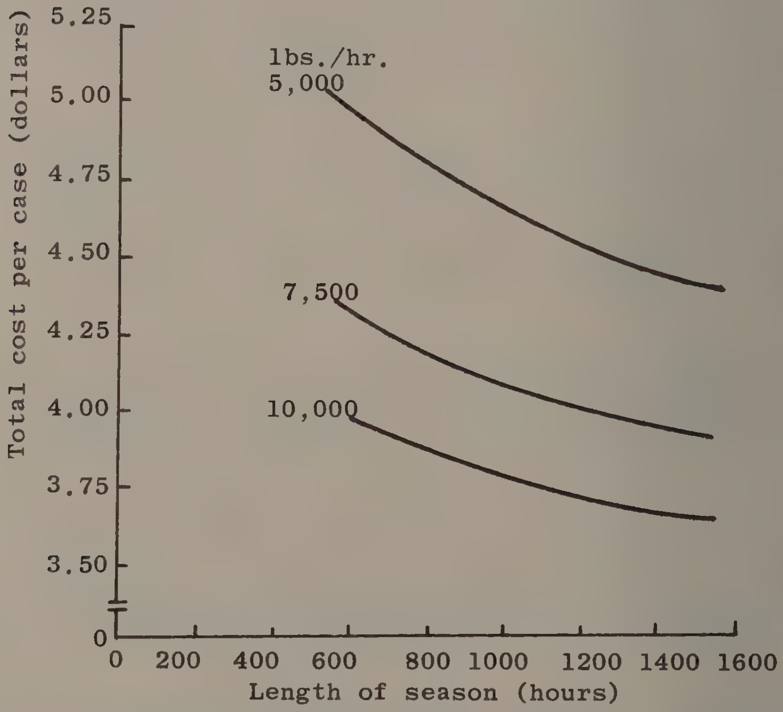


Figure 2. The relationship between less-than-capacity operation, length of season, and total cost per case of canning sweet potatoes in a 10,000-pound per hour plant with 40 percent trim and peel loss

Table 14. The effects of less-than-capacity operation of a model sweet potato canning plant designed for an 800-hour season

Item	Rate of operation		
	100 percent	75 percent	50 percent
Raw product per hour	10,000 lbs.	7,500 lbs.	5,000 lbs.
		(dollars per case)	
Cost per case			
Variable inputs	3.042	3.242	3.537
General cost	.663	.760	.933
Durable input cost	.153	.206	.303
Total	3.858	4.208	4.773

costs are sensitive to shortages of raw product which are reflected in less-than-capacity operation.

PROFITABILITY OF INVESTMENT: CAPITALIZATION METHOD

In deciding whether or not to construct a new canning plant, a significant question is the number of years necessary to recoup the initial investment. The planning horizon of the investor may not be as long as the technical life of the canning plant. For example, one might specify that he is willing to invest only if the venture will return the initial investment within a 10- or 15-year period.

For a plant operating at technical capacity, output is a function of the length of operating season. Given the output for a particular period, residual revenue attributable to the plant can be computed by subtracting total operating cost (but not interest and depreciation on the fixed investment) from total revenue generated during the period. This annual residual revenue is called quasi rent on the plant (4).

Quasi Rent. The formula for quasi rent in a given production period is expressed as:

$$(1) \quad Q_t = P_t \, q_t - C_v q_t \, .$$

Q_t = quasi rent in any given period, t,

P_t = market price of finished product in period t,

q_t = number of finished units produced and sold in period t, and

$C_v q_t$ = total variable costs in period t.

By estimating a series of quasi rents over the planning horizon or expected life of the plant and discounting at the market rate of interest, an estimated capital value of the plant can be obtained.

The estimated capital value of the stream of quasi rents $(Q_1, Q_2, \ldots, Q_T)$ from time period 1 to T is obtained as follows:

$$\text{(2a)} \quad V = \frac{Q_1}{(1 + r)} + \frac{Q_2}{(1 + r)^2} + \ldots + \frac{Q_T + S}{(1 + r)^T}, \text{ where}$$

V = the sum of discounted quasi rents, i.e., the estimated capital value of the plant,

T = the expected life of plant or the planning horizon,

r = rate of interest in market for long-term loans, and

S = expected scrap value of plant at date T.

Formula (2a) can be simplified in writing by expressing it in continuous form as (2b) $V = \int_0^T Q(t)\, e^{-rT}\, dt + Se^{-rT}$.

Investment Values. This model combines the essential variables in an investment analysis to give an estimated capital value (V) of a plant which has a known initial investment cost (C). In examining investment profitability, a comparison of V and C can lead to one of three results.

(i) $V - C < 0$, this plant has a negative investment value and it would be unprofitable to incur the cost C;

(ii) $V - C = 0$, this plant has zero investment value and indifference might exist between loaning funds in the market or investing in the plant; and

(iii) $V - C > 0$, this plant has a positive investment value and would be considered a profitable venture.

Profitability of making an investment is determined by comparing estimated capital value of the plant with its initial investment cost. The difference between capital value and initial investment cost is referred to as "investment value" of the plant.

Thus far the model has been expressed in terms of evaluating profitability of a single plant. The decision must be made at some point regarding which size plant should be constructed. Size of plant increases in a discontinuous fashion in the real world and the selection of plant size often reduces to a choice between a small number of possible sizes.

The selection of a particular plant size may proceed by evaluating first one size and then another under a variety of assumptions about the variables influencing profitability and then choosing the size having greater promise of profit maximization. However, it must be kept in mind that restrictions on both long-term loans and short-term operating funds may dictate consideration of a plant somewhat smaller than the one potentially offering greatest profits.

Estimated Quasi Rents. The revenue and cost information developed in the previous sections provides the basis for proceeding with the evaluation of investment profitability under various operating situations. The formula for estimating quasi rent is $Q_t = P_t q_t - C_v q_t$. For a model plant operated over a 600-hour season with 40 percent trim and peel loss, revenue ($P_t q_t$) is estimated as $599,000. Total costs are $590,100. Thus quasi rent for a single production period would be Q = $599,000 - $590,100 = $8,900.

Table 15 presents the estimated quasi rents for each plant for different lengths of operating season and levels of trim and peel loss. Quasi rents are also computed for each plant operating at 75 percent capacity and having 40 percent trim and peel loss.

Table 15. The relationship between quasi rent, length of operating season and trim and peel loss a/

Length of season	Trim and peel loss (percent)			
	30 b/	40 b/	50 b/	40 c/
(hours)	(quasi rent, thousand dol./year)			
600	52.9	8.9	-39.4	-21.2
800	88.9	30.2	-34.2	- 9.9
1000	124.9	51.6	-29.0	1.4
1200	160.9	72.9	-23.7	12.7
1400	196.9	94.2	-18.4	24.1
1600	233.0	115.6	-13.1	35.4

a/ Computed by subtracting total cost from total revenue.
b/ Full capacity.
c/ 75 percent capacity.

A quick scan of Table 15 reveals several negative values for quasi rent, particularly for the 50 percent trim and peel loss situation and for plants operating at 75 percent capacity. These negative values indicate that revenues are insufficient even to cover annual operating costs. For these situations it is unnecessary to estimate investment value since a negative value is certain.

Estimated Capital Values. In converting quasi rents to the capital value of each plant, assumptions about discount rate and planning horizon or expected life of the plant must be made.

A discount rate of 6 percent was assumed. The planning horizon of a potential investor will very likely be within a 15-year period. An investment which becomes profitable only when the discounted income stream extends beyond 15 years will generally be rejected by most suppliers of long-term capital. Therefore, a planning horizon of 15 years was used, even though the expected life of a canning plant usually is considered to be 20 years.

The advent of technological improvements is another strong argument for a shortened planning horizon. For example, French (5) has shown that increased efficiencies in the vegetable canning industry in the United States have been such that canning cost per unit of output increased only 31 percent from 1947 to 1959, while prices of canning inputs increased 54 percent. This is a strong indication that new plants may be faced in the future with pressures of new technology moving them into a position of cost disadvantage.

In projecting quasi rents over the 15-year planning horizon, it is also necessary to make some assumption about relative prices of both factors and products. For the time being, it was assumed that relative prices remain constant over the planning horizon. An example will be presented later where factor and product price trends were studied.

The formula used in estimating capital value of durable goods was given as $V = \frac{Q_1}{(1+r)} + \frac{Q_2}{(1+r)^2} + \ldots + \frac{Q_T + S}{(1+r)^T}$. The scrap value (S) was assumed to be zero in this analysis. It is improbable that the decision of whether or not to invest in a plant will be made in terms of expected scrap value at some future date. If investment value is negative for the appropriate horizon, the discounted scrap value very likely would be of insufficient magnitude to alter the final decision.

The assumption about constant prices over the planning horizon means that quasi rent would be equal for each year, or $Q_1 = Q_2 = \ldots = Q_T$. Therefore, the capital value formula can be reduced to $V = Qm$ for computations, where

$$m = \sum_{t=1}^{T} \frac{1}{(1+r)^t}$$

The value of m was computed with r = .06 for values of T from 1 to 15 years. This provided a figure which, when multiplied by the appropriate quasi rent, gave the estimated capital value of the plant which generated the quasi rent every year in the planning horizon. These values for 6 percent discount rate are as follows:

Planning horizon (T)	Value of m
1	.943
2	1.833
3	2.673
4	3.465
5	4.212
6	4.917
7	5.582
8	6.209
9	6.801
10	7.359
11	7.886
12	8.383
13	8.852
14	9.294
15	9.711

For this plant operating 600 hours per year, having 40 percent trim and peel loss, and quasi rent estimated as 8.9 thousand dollars, the estimated capital value of the plant (V) for a 15-year planning horizon would be 8.9 X 9.711 or approximately 86 thousand dollars.

Three lengths of operating season were used for estimating capital value of a plant with the three assumptions about trim and peel loss. In addition, the plant was assumed to operate at 75 percent capacity and 40 percent trim and peel loss to reveal the effects of less-than-capacity operation on profitability.

Estimated Investment Values. Investment value (V - C) was evaluated by a comparison of the estimated capital value (V) with initial durable input investment cost (C) for each plant. The computation of V - C for each year over the 15-year horizon indicates if and when a positive investment value ($V - C > 0$) is attained for a particular plant and assumed set of operating conditions.

It was suggested earlier that an investment analysis might proceed by evaluating each alternative size of plant and then choosing the size having the greatest potential for maximizing profit. In the analysis of this plant, full capacity operation is assumed, except where clearly specified. The initial cost of durable inputs in shown in Table 10.

Table 16 presents the estimated investment values for a model plant under operating conditions of 30 percent and 40 percent trim and peel loss and three lengths of season--600, 1000 and 1400 hours. Before proceeding further, the 30 percent trim and peel loss situation should be considered only as a worthy goal to work toward and not as something that existing plants attain regularly. In reality, the average is often close to 50 percent (6). Therefore, the 40 percent figure was included as an attainable possibility where care is taken in raw product procurement.

Table 16. The influence of length of season and trim and peel loss on the investment value of 10,000-pound per hour sweet potato canning plants

Planning horizon	Trim and peel loss a/					
	30 percent			40 percent		
	Length of season (hours)			Length of season (hours)		
	600	1000	1400	600	1000	1400
(years)	(thousand dollars)					
1	-304	-266	-228	-346	-336	-325
2	-257	-155	-53	-338	-290	-249
3	-213	-50	112	-331	-246	-162
4	-171	49	268	-324	-206	-88
5	-131	142	416	-317	-167	-17
6	-94	230	554	-311	-131	49
7	-59	313	685	-305	-96	112
8	-26	392	809	-299	-64	171
9	6	465	925	-294	-34	227
10	35	535	1,035	-289	-5	279
11	63	601	1,139	-285	22	329
12	89	662	1,237	-280	48	376
13	114	722	1,329	-276	72	420
14	137	777	1,416	-272	95	462
15	159	829	1,498	-268	116	501

a/ Investment value of plant was negative for all planning horizons at all lengths of season with 50 percent trim and peel loss as suggested by negative quasi rents shown in Table 15.

The investment value of this plant is negative over the entire 15 years for a 600-hour season and 40 percent trim and peel loss. However, as length of season moves to 1000 or 1400 hours per year, the investment value is positive at 11 and 6 years respectively (Figure 3).

If the plant experiences 50 percent loss in product in the trimming and peeling operations, then V - C < 0 would be predetermined over the entire horizon due to negative quasi rents shown in Table 15; i.e., revenue would be less than annual operating costs. Even a 1400-hour season would be insufficient to overcome the deficit where such high losses occur in the trim and peel operation.

Thus, the profitability of this plant is tied closely with ability to attain a low trim and peel loss and to operate for a relatively high number of hours each year. If type of raw product and quantity of operating capital were unavailable for attaining such goals, then profitability of such a plant would be questionable.

Figure 4 shows the effects of operating this plant at 75 percent capacity. In comparison with Figure 3, it is evident that negative investment values exist regardless of length of season operated.

Comparison with Larger Plants. Larger plants operated at capacity appear to be more profitable than a 10,000-pound per hour plant. Neither general costs nor cost of durable inputs increases proportionately with volume packed. Economies of scale contribute to larger quasi rents and therefore greater investment values.

Figures 5, 6 and 7 compare four sizes of plants operating 600-, 1000- and 1400-hour seasons with 40 percent trim and peel loss. Plants A through D illustrate 10,000-, 20,000-, 30,000- and 40,000-pound per hour plants, respectively. Operating a 600-hour season, plant A has negative investment value as shown earlier in Figure 3. Plant B has a positive investment value for a 9-year planning horizon or longer, plant C for a 7-year horizon and plant D for a 5-year horizon. Longer operating seasons shorten the length of planning horizon at which the present value of expected income equals initial cost of plant construction.

FACTORS AFFECTING PROFITS

General Price Trends. The estimated investment value of these canning plants would be considerably lower if it were assumed that recent factor and product price trends continue over the planning horizon. The canning cost per unit of output in 1957-59 was 131 percent of the 1947-49 level. This average of 3 percent per year increase was due to rising costs of inputs used in canning (2). In contrast, the wholesale prices for processed vegetables in 1957-59 were only 108 percent of 1947-49 prices, or slightly less than a 1 percent rise annually.

Assuming both factor and product prices continue the past trend, linear cost and revenue indices were constructed over the 15-year period for use in adjusting cost and revenue to compute quasi rents for each period. The quasi rents were discounted at 6 percent. Figure 8 presents the investment value for each of the 10 to 40 thousand pound per hour plants operating a 1000-hour season and having 40 percent trim and peel loss. Only plants C and D have a positive investment value during any part of the 15-year planning horizon. If these two plants continue to operate beyond 7 and 10 years, respectively, the investment value becomes negative. However, it might be possible

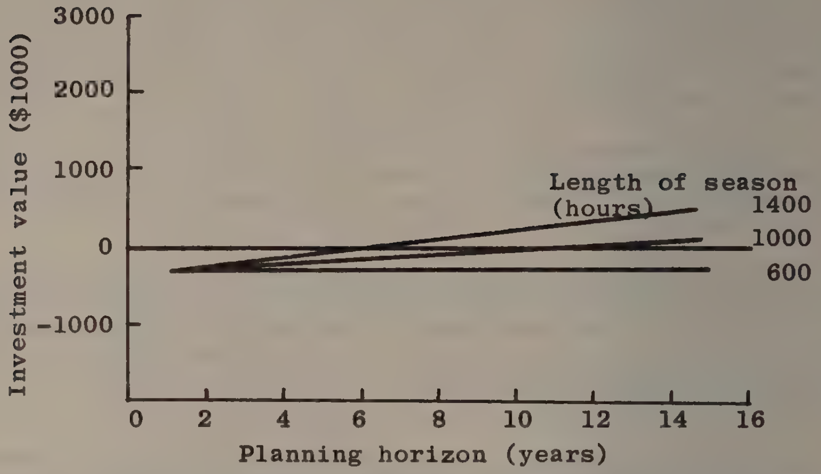


Figure 3. The influence of length of season and planning horizon on the investment value of durable goods in model sweet potato canning plants operated at full capacity with 40 percent trim and peel loss

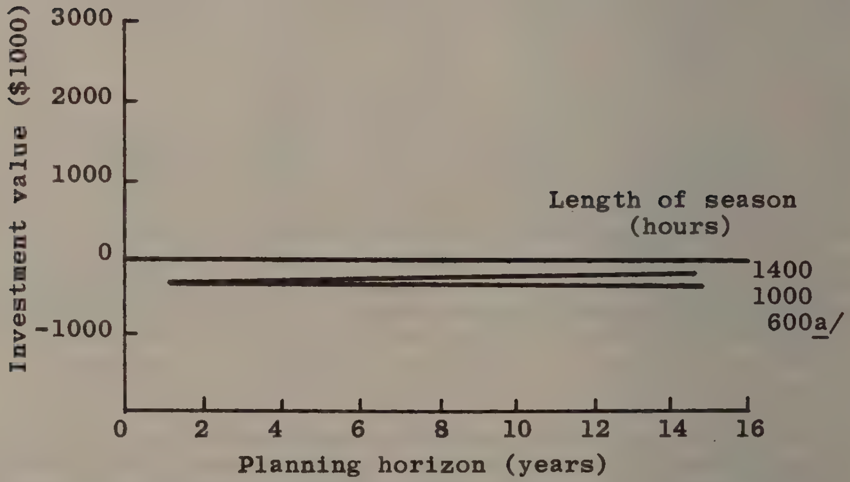


Figure 4. The influence of length of season and planning horizon on the investment value of durable goods in model sweet potato canning plants operated at 75 percent capacity with 40 percent trim and peel loss

a/ Negative investment values predetermined by negative quasi rents shown in Table 15.

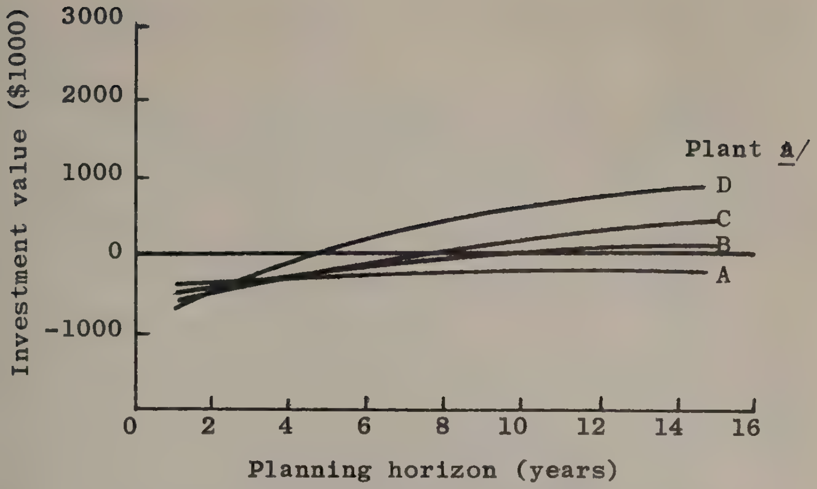


Figure 5. The relationship between planning horizon and investment value of four model sweet potato canning plants operating a 600-hour season with 40 percent trim and peel loss

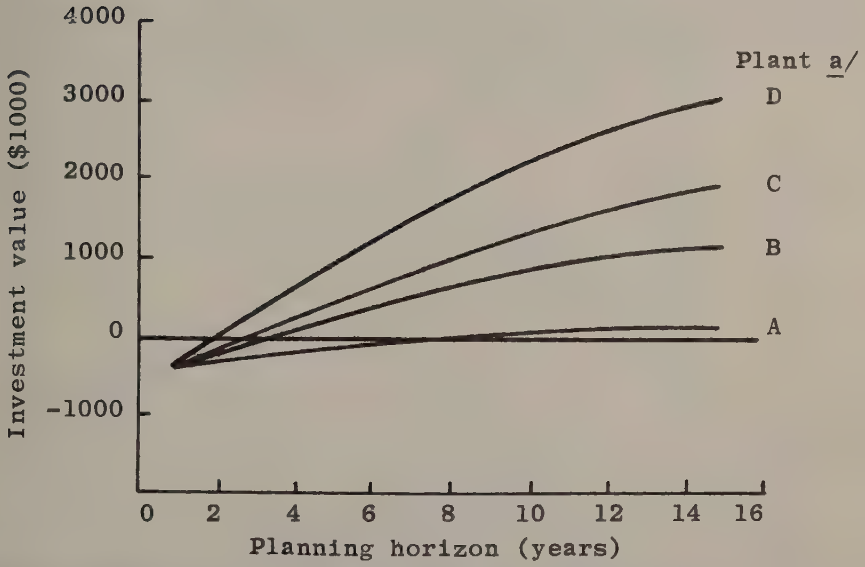


Figure 6. The relationship between planning horizon and investment value of four model sweet potato canning plants operating a 1000-hour season with 40 percent trim and peel loss

a/ Plant capacities in thousand pounds per hour are: A, 10; B, 20; C, 30; and D, 40.

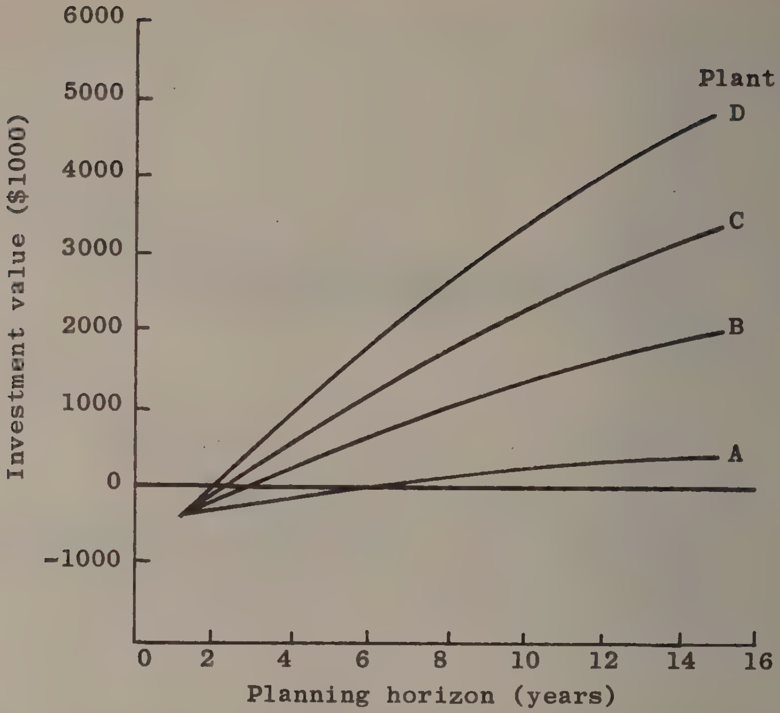


Figure 7. The relationship between planning horizon and investment value of four model sweet potato canning plants operating a 1400-hour season with 40 percent trim and peel loss

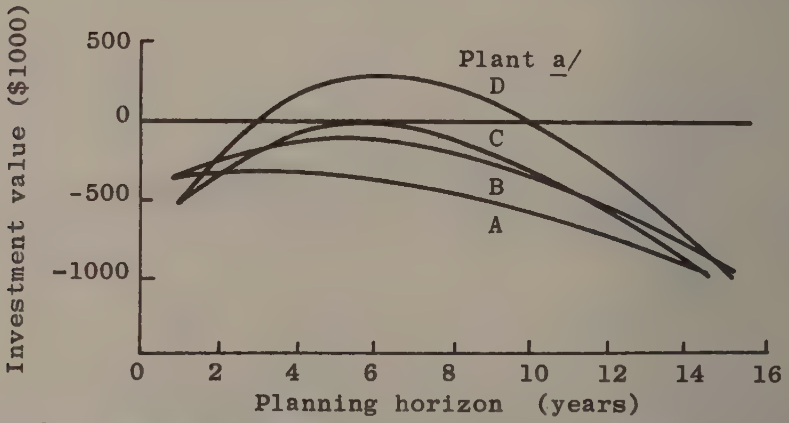


Figure 8. The investment value of durable goods in four model sweet potato canning plants operating a 1000-hour season with 40 percent trim and peel loss and factor prices increasing relative to product prices at recent rates over the planning horizon

a/ Plant capacities in thousand pounds per hour are: A, 10; B, 20; C, 30; and D, 40.

for the two plants to install certain new cost reducing technologies during the time that operation was profitable and in this manner extend the economic life of the plant.

This example of possible price trends which might influence profitability of an investment also demonstrates how the economic life of a durable goods investment may be, and often is, less than the expected technical life. Changing cost and revenue possibilities lends another strong argument supporting potential investors' utilization of short planning horizons rather than relying too heavily on expected conditions which may or may not prevail in the distant future.

Many assumptions were necessary in this analysis to handle the numerous variables involved. Among the more important assumptions were those dealing with the price of raw product, wage rates, and prices of the finished product. The effects of recent trends have been demonstrated. However, it is important to be aware of the sensitivity of the analysis to absolute changes in prices of inputs and products.

Raw Product Price. One fourth of the variable input costs of canning sweet potatoes consists of payment for the raw product. Throughout this analysis it is assumed that an adequate supply of raw sweet potatoes is available at $2.00 per cwt. (Table 5). A 10 percent change in raw product price (20 cents per cwt.) would change hourly operating costs for a 10,000-pound per hour plant operating at capacity by $20 per hour or 7.7 cents per case. Larger changes in price would be proportional to this amount as shown below for a plant operating 800 hours per season.

Raw product price	Variable input costs	Total costs
(dollars per cwt.)	(dollars per case)	
1.80	2.965	3.781
2.00	3.042	3.858
2.20	3.119	3.935
2.40	3.196	4.012

Wage Rate. A basic wage rate of $1.00 per hour was used in this analysis. Since a few jobs commanded higher rates, the average rate used was $1.08 per hour for labor used directly in the canning operation. Approximately 15 percent of variable input costs of canning were associated with direct labor. A 10 percent change in rate would change hourly operating costs for a 10,000-pound per hour plant by $11.57 per hour or 4.5 cents per case.

Container Costs. The largest variable cost group is cans, cases and labels which together made up 43 percent of all variable input costs. A 10 percent change from the price level shown in Table 5 would change costs $34 per hour or 13.1 cents per case for a 10,000-pound per hour plant operating at capacity.

Finished Product Price. In this analysis a price of $3.86 per case was used which represented a weighted average price for the assumed distribution of cans by size as shown in Table 3. At this price the 800-hour operation would just break even with capacity operation. The 1600-hour operation costs $3.658 per case (Table 13) and would just break even with a 20-cent, or 5 percent reduction in price.

The effects of simultaneous changes in the prices of the finished product, raw product and wage rate are shown in Table 17. Here the effect was measured in terms of the investment value of the plant discussed in the preceeding section of this report. High finished product prices and lower raw product price or wage rates increase the investment value of this plant substantially. However, less favorable levels result in failure to cover operating and durable input costs.

This brief examination of the sensitivity to different assumptions indicates that a plant would be likely to experience economic difficulties if finished product prices move much lower than the base level used in this report. The same would be true if wage rates or raw product prices were at high levels. This sensitivity should be kept in mind when considering the building of a new plant and the probable influence of new competitions on prices.

Table 17. The influence of finished product price, raw product price and wage rate on investment value of a sweet potato canning plant a/

Item	Finished product price (dollars per case)			
	3.50	3.86	4.00	4.20
		(thousand dollars)		
Raw product price:				
$1.60 per cwt.	neg.b/	325	545	847
1.80 per cwt.	neg.b/	209	428	730
2.00 per cwt.	neg.b/	92	312	614
2.20 per cwt.	neg.b/	neg.b/	194	497
Wage rate:				
$ .97 per hour	neg.b/	162	382	684
1.08 per hour	neg.b/	92	312	614
1.19 per hour	neg.b/	22	242	544

a/ The initial cost of a 10,000-pound per hour plant designed to operate a 600-hour season with 40 percent trim and peel loss is $354,000. A 15-year planning horizon is assumed.

b/ Negative value resulting from cost exceeding revenue.

Note: Underlined value is the base wage rate and product price used in this analysis. This indicates that a loss of $262,000 would be sustained under the assumed base conditions.

CONCLUSIONS

The profitability of investing in a sweet potato processing plant depends primarily on the ability of investors to insure certain conditions which appear essential to survival and growth. One major requirement is available capital. The initial investment in a 10,000-pound per hour plant described here will range from $354,000 to $430,000 depending on warehouse capacity.

Working capital requirements are even larger than long-term capital needs. For example, general costs will run from $117,000 to $219,000 per season. Variable inputs will cost between $473,000 for a 600-hour season to $1,261,000 for a 1600-hour season. If sales are spread evenly throughout the year, maximum inventory of canned goods will range from $315,000 to $840,000 at the close of the 15-week canning season.

Before constructing a canning plant, the investor must consider the quantity and quality of raw product available. For the plants described here, raw product needed will range from 6 million to 16 million pounds annually. If supplies are short or if short-term capital limits the quantity which can be purchased, a plant will operate below capacity with the resulting increase in cost per case.

In addition to capital availability and raw product supply, new canning firms must consider the possibility of granting price reductions as a form of entry cost to gain acceptance by buyers. If price concessions are made, this will delay the time at which initial investment will be regained. Price concessions might lead to counter moves by competing canning plants which might lead to a general reduction in prices.

Research shows that plants operating at 20 to 40 thousand pounds per hour have somewhat lower costs than 10,000-pound plants. In interviews with plant operators in North Carolina and Louisiana, four of the six were in the 10,000-pound category. Trim and peel loss ranged between 40 and 50 percent. The only plants operating 1000 hours or more per season were in Louisiana.

Increasing the number of specialized sweet potato canning plants in North Carolina should be considered carefully in the light of available capital, raw product supply and the short canning season relative to Louisiana. Expansion of existing plants or conversion to multiple product operations may be preferable to increasing plant numbers.

APPENDIX

Appendix Table 1. Number of cans per case and net weight of sweet potatoes by size of can

Can size	Cans per case	Net weight of sweet potatoes a/	
		Per can	Per case
	(number)	(ounces)	(pounds)
303	24	11.5	17.25
3 squat	24	15.0	22.50
2 1/2	24	19.0	28.50
10	6	72.0	27.00

a/ Computed on a drained weight basis.

Appendix Table 2. Job description and work standards for direct labor in sweet potato canning operations

Job description	Unit	Work standard (units/hr.)
Receive raw product	pounds	20,000
Operate dump	pounds	40,000
Tend lye tank	pounds	40,000
Wash and peel attendant	pounds	40,000
Trim		
30 percent trim and peel loss	pounds	186
40 percent trim and peel loss	pounds	177
50 percent trim and peel loss	pounds	167
Slicer attendant	pounds	6,350
Fill - 2 1/2	cases	27
303	cases	24
3 squat	cases	25
10	cases	21
Mix syrup	pounds	10,000
Closing machine - 2 1/2	cases	84
303	cases	96
3 squat	cases	95
10	cases	100
Empty can supply- 2 1/2	cases	107
303	cases	110
3 squat	cases	110
10	cases	102
Closing to retort	retort crates a/	50
Retort operator	retort crates a/	7
Away from retort	retort crates a/	50
Crate dump	retort crates a/	139
Label machine	cases	542
Form cases	cases	239
Casing - 2 1/2	cases	246
303	cases	356
3 squat	cases	154
10	cases	136
Stack cases	cases	360

a/ One retort crate holds 10 cases of 2 1/2 cans; 18 cases of 303; 10 cases of No. 10; and 12.5 cases of 3 squat cans.

Appendix Table 3. Crew requirements and direct labor cost per hour of plant operation in sweet potato canning plant receiving 10,000 pounds per hour a/

Job	Wage rate	30 percent trim and peel loss		50 percent trim and peel loss	
		Workers	Direct labor cost	Workers	Direct labor cost
	(dol./hr.)	(no.)	(dol./hr.)	(no.)	(dol./hr.)
Receive raw product	1.73	1	1.73	1	1.73
Operate dump	1.05	1	1.05	1	1.05
Tend lye tank	1.73	1	1.73	1	1.73
Wash and peel attendant	1.05	1	1.05	1	1.05
Trim	1.05	54	56.70	60	63.00
Slicer attendant	1.05	2	2.10	2	2.10
Fill: 2 1/2	1.05	3	3.15	2	2.10
303	1.05	3	3.15	3	3.15
3 squat	1.05	5	5.25	4	4.20
10	1.05	2	2.10	2	2.10
Mix syrup	1.05	1	1.05	1	1.05
Closing machine: 2 1/2	1.05	1	1.05	1	1.05
303	1.05	1	1.05	1	1.05
3 squat	1.05	2	2.10	1	1.05
10	1.05	1	1.05	1	1.05
Empty can supply: 2 1/2	1.05	1	1.05	1	1.05
303	1.05	1	1.05	1	1.05
3 squat	1.05	1	1.05	1	1.05
10	1.05	1	1.05	1	1.05
Closing to retort	1.05	1	1.05	1	1.05
Retort operator	1.26	4	5.04	3	3.78
Away from retort	1.05	1	1.05	1	1.05
Crate dumper	1.05	1	1.05	1	1.05
Label machine	1.05	1	1.05	1	1.05
Form cases	1.05	2	2.10	1	1.05
Casing: 2 1/2 and 303	1.05	1	1.05	1	1.05
3 squat and 10	1.05	2	2.10	1	1.05
Case stacker	1.05	1	1.05	1	1.05
Fork lift driver:					
Raw product receipt	1.05	1	1.05	1	1.05
Dump	1.05	1		1	
Cannery to warehouse	1.05	1	1.05	1	1.05
Warehouse	1.05	2	2.10	1	2.10
Boiler attendant	1.30	1	1.30	2	1.30
Clean-up	1.05	3	3.15	3	3.15
Supervisor - Trim	1.58	1	1.58	1	1.58
Closing	1.58	1	1.58	1	1.58
Total		107	115.86	107	115.65

a/ Assuming the following pack distribution: 2 1/2 - 23 percent; 303 - 24 percent; 3 squat - 38 percent; and 10 - 15 percent.

Appendix Table 4. The relationship between sugar requirements, can size, and Brix concentration of syrup in sweet potato canning operations

Can size	Syrup a/	Brix concentration of syrup				
		20°	25°	30°	35°	40°
	(lbs./case)		(lbs./case)			
303	8.8	1.8	2.2	2.6	3.1	3.5
3 squat	12.0	2.5	3.2	3.8	4.4	5.0
10	14.7	2.9	3.7	4.4	5.2	5.9
2 1/2	15.5	3.1	3.9	4.7	5.4	6.2

---

a/ Includes 5 percent allowance for spillage and waste. Basic figures on quantity of syrup in each can size were provided by food processing specialists who have conducted research with different syrup concentrations.

Appendix Table 5. The relationship of can requirements, percent trim and peel loss and can size in sweet potato canning operations

Can size	Trim and peel loss (percent)		
	30	40	50
		(cans/thousand pounds dumped) a/	
303	974	835	696
3 squat	746	641	533
2 1/2	590	506	420
10	155	133	111

---

a/ Does not include 5 percent allowance for damaged cans. Can requirements are computed on the basis of 1,000 pounds for each can size, i.e., no distribution between can sizes is assumed.

Appendix Table 6. Total water requirements in sweet potato canning operations, 10,000 pounds raw product per hour

Purpose	Quantity of water used
	(gallons/hour)
Production line a/	18,000
Boiler b/	621
Syruper c/	687
Total	19,308

---

a/ Specified by equipment companies.
b/ Specified by boiler company.
c/ Related to quantity of syrup used.

Appendix Table 7. Input data and estimated variable costs for 10,000-pound per hour sweet potato canning plant, 30 and 50 percent trim and peel loss a/

Item	Unit	Price per unit	30 percent trim and peel loss		50 percent trim and peel loss	
			Quantity	Cost	Quantity	Cost
		(dol.)	(unit/hr.)	(dol./hr.)	(unit/hr.)	(dol./hr.)
Raw product	cwt.	2.00	100.000	200.00	100.000	200.00
Direct labor	man-hrs.	b/	107.000	115.86	107.000	115.86
Sugar (30° Brix syrup)	cwt.	10.00	11.450	114.50	8.180	81.80
Lye	gallon	.25	42.500	10.63	42.500	10.63
Cans c/ - 2 1/2	M	51.00	1.740	88.74	1.235	62.98
303	M	33.50	1.840	61.64	1.310	43.90
3 squat	M	51.00	2.898	147.80	2.066	105.37
10	M	125.22	.277	34.69	.202	25.30
Labels d/ - 2 1/2	M	3.80	1.904	7.24	1.352	5.14
303	M	2.80	2.015	5.64	1.435	4.02
3 squat	M	3.15	3.174	10.00	2.263	7.13
10	M	8.65	.304	2.63	.221	1.91
Cases - 2 1/2	M	113.00	.069	9.18	.049	6.52
303	M	107.00	.073	7.81	.052	5.56
3 squat	M	142.00	.115	16.33	.082	11.64
10	M	131.00	.044	5.76	.032	4.19
Power	kwh	.0134	63.000	.84	63.000	.84
Water	M gal.	.150	19.300	2.90	.150	2.90
Fuel	gallon	.155	54.000	8.37	.155	8.37
Variable repairs e/		-	-	11.03		11.03
Total variable costs				861.59		714.88

a/ Assuming the following distribution of pack: No. 2 1/2 cans - 23 percent; No. 303 cans - 24 percent; No. 3 squat cans - 38 percent and No. 10 cans - 15 percent.

b/ Wage rates vary by job, see Appendix Table 6.

c/ Allows 5 percent for damaged cans.

d/ Allows 15 percent for damaged labels.

e/ Computed as 0.5 percent of replacement value per 100 hours of operation.

Appendix Table 8. The price of canned sweet potatoes packed in syrup, F.O.B. Virginia-Maryland area, 1955-1960

Year	Can size			
	2 1/2	303	3 squat	10
	(dollars/case) a/			
1955	3.94	2.70	3.54	3.50
1956	4.30	2.82	3.98	3.65
1957	4.58	2.94	4.26	3.72
1958	4.68	2.52	4.50	4.61
1959	5.04	2.58	4.36	4.75
1960	4.50	2.50	3.96	4.75
Average, 1955-60	4.50	2.68	4.10	4.16

---

a/ No. 2 1/2 - 24 cans per case; No. 303 - 24 cans per case; No. 3 squat - 24 cans per case; and No. 10 - 6 cans per case.

Appendix Table 9. Accumulated total variable costs and monthly inventory balance in 10,000-pound per hour sweet potato canning plant (assuming 40 percent trim and peel loss) a/

Month	Length of operating season (hours)					
	600	800	1000	1200	1400	1600
	Accumulated variable cost (thousand dollars) b/					
September	118.2	157.6	197.0	236.4	275.8	315.2
October	236.4	315.2	394.0	472.8	551.6	630.4
November	354.6	472.8	591.0	709.2	827.4	945.6
December	472.8	630.4	788.0	945.6	1,103.2	1,260.8
	Inventory balance (thousand dollars) c/					
September	78.8	105.1	131.3	157.6	183.9	210.1
October	157.6	210.1	262.7	315.2	367.7	420.3
November	236.4	315.2	394.0	472.8	551.6	630.4
December	315.2	420.3	522.3	630.4	735.5	840.5
January	275.8	367.7	459.7	551.6	643.5	735.5
February	236.4	315.2	394.0	472.8	551.6	630.4
March	197.0	262.7	328.3	394.0	459.7	525.3
April	157.6	210.1	262.7	315.2	367.7	420.3
May	118.2	157.6	197.0	236.4	275.8	315.2
June	78.8	105.1	131.3	157.6	183.9	210.1
July	39.4	52.5	65.7	78.8	91.9	105.1
August	-	-	-	-	-	-
Total	1,891.2	2,521.6	3,149.0	3,782.4	4,412.8	5,043.2
Average	157.6	210.1	262.4	315.2	367.8	420.3

---

a/ Assuming the following distribution of pack: No. 2 1/2 cans - 23 percent; No. 303 cans - 24 percent; No. 3 squat cans - 38 percent; and No. 10 cans - 15 percent.

b/ $788 per hour, see Table 5.

c/ Assumes even distribution of sales over 12-month period and zero carry over.

Appendix Table 10. General plant costs with 30 percent and 50 percent trim and peel loss in a 10,000-pound per hour sweet potato canning plant

Item	Length of season (hours)					
	600	800	1000	1200	1400	1600
	(thousand dollars per year)					
30 percent trim and peel loss:						
Salaries, taxes, and repairs a/	51.7	52.0	52.5	52.8	53.2	53.5
Office and sales expense b/	55.7	74.3	92.9	111.5	130.0	148.7
Insurance and interest c/	18.3	22.9	27.5	32.1	36.6	41.2
Total general costs	125.7	149.2	172.9	196.4	219.8	243.4
50 percent trim and peel loss:						
Salaries, taxes and repairs a/	51.6	52.0	52.4	52.8	53.1	53.5
Office and sales expense b/	39.8	53.1	66.3	79.6	92.8	106.1
Insurance and interest c/	15.9	19.6	23.5	27.3	31.0	34.8
Total general costs	107.3	124.7	142.2	159.7	176.9	194.4

a/ See Table 9 for details.
b/ Two and 6 percent of sales, respectively.
c/ See Tables 8 and 10 for details.

Appendix Table 11. Space requirements and initial investment cost of building for 10,000-pound per hour sweet potato canning plants operating 600- to 1600-hour seasons

Use of space	Space required (sq. feet)	Initial investment (dollars) a/
Processing and related areas		
Canning plant b/	25,600	74,200
Boiler room c/	800	2,300
Service area c/	1,200	3,500
Office space c/	500	3,500
Total nonstorage area	28,100	83,500
Storage area d/		
600-hr. season	15,000	37,500
800-hr. season	20,000	50,000
1000-hr. season	25,000	62,500
1200-hr. season	30,000	75,000
1400-hr. season	35,000	87,500
1600-hr. season	40,000	100,000

---

a/ Based on an estimate of $2.90 per square foot for metal prefabricated type building including 5 inches reinforced concrete floor, plumbing, heating, and electrical wiring for canning plant, boiler room and service area; $6.90 per square foot of area furnished for office space; and $2.50 per square foot for storage area.

b/ Estimated from information provided by equipment companies and survey of existing plants.

c/ Estimated from survey of existing plants.

d/ Assumed that two-thirds of season's output will be in storage at peak requirement for space at 15 square feet per 100 cases.

Appendix Table 12. Equipment list and installed cost for 10,000-pound per hour sweet potato canning plant

Equipment	Power unit	Equipment unit	Equipment cost a/
	(horsepower)	(number)	(dollars)
Pallet box dump	3/4	1	1,995
Elavator	3/4	1	800
Rotary washer	3/4	1	1,525
Elevator	3/4	1	800
Preheater	2 3/4	1	4,725
Lye peeler	2 3/4	1	5,825
Washer	1	1	2,468
Cross conveyor	-	-	-
Trimming table	1 1/2	1	3,200
Elevator	3/4	1	1,000
Cross conveyor	-	-	-
Grader (sizer) and accum. belts	1	1	2,800
Cross conveyor	3/4	1	600
Halver	1	1	1,500
Quartering machine	1	1	1,170
O. V. slicer	2	1	3,073
Cross conveyor	-	-	-
Hand pack fillers	1	2	4,780
Cross conveyor	-	-	-
Syrupers - 12 valve	4	2	11,464
Exhaust boxes	2	2	7,950
Closing machines			
2 1/2	2	1	12,170
303	2	1	12,170
3 squat	2	1	14,925
10	2	1	5,205
Retort crates	-	60	1,980
Overhead hoist (includes monorail system)	1 1/2	1	4,244
Retorts	-	10	6,000
Overhead hoist (for retorts)	1 1/2	1	4,244
Cooling canal	-	1	7,000
Overhead hoist	1 1/2	1	4,244
Dump and unscrambler	1 1/2	1	10,000
Labeling machine	1/2	1	3,070
Casing machine			
2 1/2 and 303	1/2	1	950
3 squat and 10	1/2	1	950
Case sealer	1	1 b/	5,000
Boiler	15	150	16,500

Appendix Table 12 (continued)

Equipment	Power unit (horsepower)	Equipment unit (number)	Equipment cost a/ (dollars)
Oil storage tank (10,000 gallons)	-	1	850
Lye storage tank (10,000 gallons)	-	1	850
Syrup-mixed (100 gallons)	1	2	1,772
Fork lift truck (4,000 lbs.-pneumatic)	-	1	6,500
Fork lift truck (4,000 lbs.-cushioned)	-	3	18,300
Total	57		192,599
15 percent for transportation and installation			28,889
Total installed cost			221,488

---

a/ Includes power unit.
b/ Boiler horsepower rating.

Appendix Table 13. Requirements and cost of bins and pallets for 10,000-pound per hour canning plants operating 600- to 1600-hour seasons

	Pallets b/					
	Length of operating season (hours)					
Bins a/	600	800	1000	1200	1400	1600
			(number)			
300	3,300	4,400	5,500	6,500	7,600	8,700
			(initial cost in dollars)			
4,500	7,400	9,800	12,300	14,700	17,200	19,600

---

a/ Enough bins are provided to have 40 hours required raw product on hand. Bin cost is estimated at $15 each.

b/ Requirements computed on basis of peak storage of two-thirds of total season output and following number of cases per pallet for different can sizes: No. 2 1/2 - 32; No. 303 - 60; No. 3 squat - 28; and No. 10 - 20. Pallet cost is estimated at $2.25 per 40 X 48 inch reversible pallet.

Appendix Table 14. Effect of less-than-capacity operation of model sweet potato canning plant with 40 percent trim and peel loss

Item	75 percent of capacity						50 percent of capacity					
	600	800	1000	1200	1400	1600	600	800	1000	1200	1400	1600
	(dollars per case)											
Durable input costs:												
Depreciation on durables:												
Building	.024	.018	.015	.012	.010	.009	.036	.027	.021	.018	.015	.013
Storage space	.010	.011	.011	.010	.011	.011	.015	.016	.016	.016	.016	.016
Bins and pallets	.010	.009	.009	.009	.008	.008	.015	.013	.013	.013	.012	.011
Equipment	.128	.096	.077	.064	.005	.048	.188	.141	.113	.094	.081	.071
Total depreciation	.173	.134	.111	.095	.084	.075	.254	.198	.163	.141	.124	.111
Interest on durables	.092	.072	.060	.052	.046	.042	.135	.106	.088	.076	.068	.062
Total durable input costs	.264	.206	.170	.147	.130	.117	.389	.303	.251	.217	.191	.173
Variable input costs:												
Raw product	.777	.777	.777	.777	.777	.777	.763	.763	.763	.763	.763	.763
Direct labor	.599	.599	.599	.599	.599	.599	.883	.883	.883	.883	.883	.883
Sugar, cans, cases	1.745	1.746	1.746	1.745	1.745	1.745	1.715	1.715	1.715	1.714	1.714	1.715
Other	.120	.120	.120	.120	.120	.120	.177	.177	.177	.177	.177	.177
Total variable input costs	3.242	3.242	3.242	3.242	3.242	3.242	3.538	3.537	3.537	3.538	3.537	3.537
General costs:												
Salaries, taxes and repairs	.446	.337	.272	.228	.197	.173	.657	.496	.400	.336	.290	.255
Office and sales expenses	.309	.309	.309	.309	.309	.309	.309	.309	.309	.309	.309	.309
Insurance and interest	.124	.115	.109	.104	.102	.100	.142	.128	.119	.114	.109	.106
Total general costs	.879	.760	.689	.641	.607	.582	1.108	.933	.828	.758	.707	.670
Total plant costs	4.385	4.209	4.102	4.030	3.979	3.941	5.036	4.774	4.617	4.513	4.436	4.380

LIST OF REFERENCES

1. Amedro, R. C. 1960. The use of caustic soda for peeling sweet potatoes. Technical Service Report No. C-2846-60, Allied Chemical Corporation, Syracuse.

2. French, B. C. 1960. Cost and factor price changes in the vegetable producing and processing industries, 1947-59. Unpublished manuscript, University of California, Berkeley.

3. French, B. C., Sammet, L. L. and Bressler, R. G. 1956. Economic efficiency in plant operations with special reference to the marketing of California pears. Hilgardia No. 19, Vol. 24, University of California, Berkeley.

4. Lutz, F. A. and Lutz, V. C. 1951. The Theory of Investment of the Firm. Princeton University Press, Princeton.

5. Sammet, L. L. and Hassler, J. B. 1951. Use of the ratio-delay method in processing plant operations. Agricultural Economics Research, Vol. 3, No. 4, U. S. Government Printing Office, Washington.

6. Woodroof, J. G., Dupree, W. E. and Cecil, S. R. 1956. Canning sweet potatoes. Agricultural Experiment Station Bul. N. S. 12, Georgia Experiment Station, Experiment.

Agricultural Experiment Station

North Carolina State College

Raleigh, N. C.

R. L. Lovvorn, Director of Research

Bulletins of this station will be sent free to all citizens who request them.

A. E. Information Series No. 97
Department of Agricultural Economics
North Carolina State College
Raleigh, North Carolina
December, 1962

PLANNING DATA FOR THE SWEET POTATO INDUSTRY

3. Selection of the Optimum Number, Size and Location of Processing Plants In Eastern North Carolina

635.1/U42
M431P
v.3

PLANNING DATA FOR THE SWEET POTATO INDUSTRY

3. Selection of the Optimum Number, Size and Location of Processing Plants In Eastern North Carolina

Gene A. Mathia
Graduate Assistant

Richard A. King
M. G. Mann Professor

A. E. Information Series No. 97
Department of Agricultural Economics
North Carolina State College
Raleigh, North Carolina
December, 1962

PREFACE

This report is the third in a series on Planning Data for the Sweet Potato Industry. It provides information concerning the current efficiency of the sweet potato processing industry as well as providing a base for planning future changes in the number, size and location of processing plants in North Carolina.

The first report in this series on Planning Data for the Sweet Potato Industry is entitled "Prices, Production and Assembly Costs" by Gene A. Mathia and Richard A. King. The second report is entitled "Costs and Returns for a Model Canning Plant" by Leigh H. Hammond and Richard A. King. This third report is based upon a doctoral dissertation submitted by the major author to the Graduate School, North Carolina State College, Raleigh. The section dealing with costs of sweet potato processing draws heavily on the study by Leigh H. Hammond entitled "An Evaluation of the Opportunity for Investment in Sweet Potato Canning Plants in North Carolina."

These studies contribute to the regional program of vegetable marketing research being conducted in the southern region under SM-8, Evaluation of Alternative Vegetable Marketing Organization and Handling Methods. Other agencies cooperating in this research are the agricultural experiment stations in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Puerto Rico, South Carolina, Tennessee, Texas and Virginia and the Marketing Economics Division of the United States Department of Agriculture.

* * * * * * * * * * *

TABLE OF CONTENTS

Page

INTRODUCTION 5

COSTS OF ASSEMBLING SWEET POTATOES 13

COSTS OF SWEET POTATO PROCESSING 18

RELATIONSHIP BETWEEN PLANT NUMBERS AND COSTS 29

THE OPTIMUM NUMBER, SIZE AND LOCATION OF PROCESSING PLANTS 36

CONCLUSIONS 61

LIST OF REFERENCES 67

APPENDIX 68

SUMMARY

This is a study of the optimum number, size and location of sweet potato processing plants in 43 counties in eastern North Carolina. Among the variables considered were the quantity of potatoes produced, production density, assembly costs and processing costs. Only specialized sweet potato canning plants were considered.

Commercial production on farms growing 5 or more acres of sweet potatoes in 1960 was provided by the Federal-State Crop Reporting Service on a township basis. Production in the 138 townships with 30 acres or more of sweet potato production totaled 1,053.4 thousand hundredweight. Four levels of output representing 10, 20, 30, and 40 percent of the total were used in the study. The quantity actually processed in 1960 represented about 7 percent of this total.

An economic-engineering approach was used to estimate assembly and processing costs. Twenty-two potential plant sites were considered. It was assumed that (1) a single assembly cost relationship is appropriate for all supply origins, (2) at all potential sites processing plants have a comparable cost structure with constant marginal costs and (3) the f.o.b. raw product price at all plants is $2.00 per hundredweight.

Assembly costs were minimized first by choosing the optimum location for plant numbers ranging from 1 to 22. Processing costs were then added. The optimum number, size and location of plants was that combination for which the sum of assembly and processing costs was as small as possible.

It was found that at all four levels of output, assembly and processing costs were minimized by a single processing plant located at Faison. The optimum size of this plant depended upon the assumed level of output. Location of a single plant at Smithfield, Benson, Magnolia, Wilson or Kinston instead of at Faison increased combined assembly and processing costs by less than 1 percent.

The best locations for two processing plants were Benson and Williamston. Combined costs for the best two-plant locations at the lowest output level were 6.3 percent above the best one-plant location. Combined costs for one- and two-plant industries were equal when the quantity of potatoes processed reached 52 percent of 1960 commercial production in the supply area studied. The optimum plant sizes varied with the level of output considered.

Optimum locations for three plants were Benson, Williamston and Chadbourn. Over 88 percent of 1960 production was needed in order for combined costs for two- and three-plant industries to be equal.

Optimum locations for four plants were Benson, Chadbourn, Greenville and Elizabeth City. Over 319 percent of 1960 commercial production in the supply area studied was needed to achieve equal combined costs for the three- and four-plant industries.

Three plants are now located at Williamston, Tabor City and Lumberton. Combined costs estimated for these sites were higher than combined costs for the best one-, two- or three-plant industries but lower than the best four-plant industry. The study indicates that savings in processing costs exceed the increases in assembly costs by 5 percent when one plant processes the commercial production in the 138 townships instead of three.

PLANNING DATA FOR THE SWEET POTATO INDUSTRY

3. Selection of the Optimum Number, Size and Location of Processing Plants In Eastern North Carolina

Gene A. Mathia* and Richard A. King**

INTRODUCTION

Industrialization may be an important element in improving farm income in North Carolina. Industrialization may utilize both agricultural products and underemployed agricultural resources, among which labor is perhaps the most important. An industry that uses farm products as a raw material can provide a direct opportunity for off-farm employment of some "excess" labor and an indirect opportunity on the farm by expanding the market for agricultural products.

The sweet potato processing industry is one which can perform this function by transforming the raw agricultural product into a consumer product with the desired characteristics. A research study conducted by Pasour and Toussaint (1960) provides information regarding the production possibilities for sweet potatoes as well as other farm products in North Carolina. On farms where labor is plentiful relative to land and capital, sweet potatoes are a good alternative. This resource situation is common on many farms in the Coastal Plain of North Carolina.

North Carolina is the second largest sweet potato producing state in the nation. North Carolina produced 2,160,000 hundredweight valued at $9,440,000 in 1959. Yet, disposition data indicated that sweet potato sales amounted to 1,250,000 hundredweight valued at $5,470,000 (N. C. Dep. Agr., 1962). This means that only 58 percent of total production enters marketing channels. For the nation, the portion sold off farms is about 68 percent.

---

*Assistant Professor of Agricultural Economics, Oklahoma State University, formerly Graduate Assistant, Department of Agricultural Economics, N. C. State College.

**M. G. Mann Professor of Agricultural Economics, N. C. State College.

The smaller proportion of North Carolina total production which enters the marketing channels reflects small acreage per farm and implies either that sweet potato marketing firms are so located that returns from sales are less than returns from on-farm uses or that facilities are not available for marketing this residual production.

Sweet potato producers in North Carolina have in the past relied heavily on selling raw sweet potatoes on the fresh market. Several fresh markets are now located throughout the sweet potato producing area of North Carolina. These markets handle a very large proportion of the total volume of potatoes that is sold. Yet, only about 65 percent of total production is of a size preferred on the fresh market. Jumbo or small sized potatoes of high quality can be transformed into a desirable product by processing. However, Hammond (1961) showed that a processing plant requires a large volume to operate profitably. Profitable operation of processing plants involves not only competition with the fresh market for a larger proportion of present production but also calls for the stimulation of more production in North Carolina as this study will demonstrate.

The organization structure of the processing industry should satisfy certain economic conditions. These conditions refer to the relationship of number, size and location of processing plants to the pattern of sweet potato production, assembly and processing costs. Three sweet potato processing plants were in operation in 1960. Before the establishment of more sweet potato processing plants in North Carolina is encouraged, research is needed to provide information concerning the conditions of production, assembly and processing costs under which additional plants might improve the income situation of either producers or processors.

The Objective

The general objective of this study is to provide information concerning efficient organization or reorganization of the North Carolina sweet potato processing industry which would improve the income situation of sweet potato producers and processors.

Specific objectives of this analysis are:

1. To ascertain the location and density of sweet potato production.
2. To estimate the costs of assembling sweet potatoes.
3. To develop a generalized method for estimating sweet potato processing costs.

4. To identify the optimum number, size and location of processing plants in eastern North Carolina.

5. To evaluate the effects of changes in raw product supply on the optimum plant pattern.

Sources of Data

Data needed to determine the optimum number, size and location of sweet potato processing plants include the location and quantity of the raw product to be processed, the location of potential plant sites, the transportation cost table from each production point to each site and processing costs expressed in terms of level of output, length of season, trim and peel loss and product prices.

Information regarding 1960 production was provided by the Federal State Crop Reporting Service, Raleigh, North Carolina, by township for those farms having 5 or more acres of potatoes. Townships with 30 or more acres harvested in 1960 were selected to represent the commercial sweet potato producing areas of North Carolina. Commercial production in each of the 138 townships selected in the 43 eastern counties of North Carolina is shown by county in Figure 1.

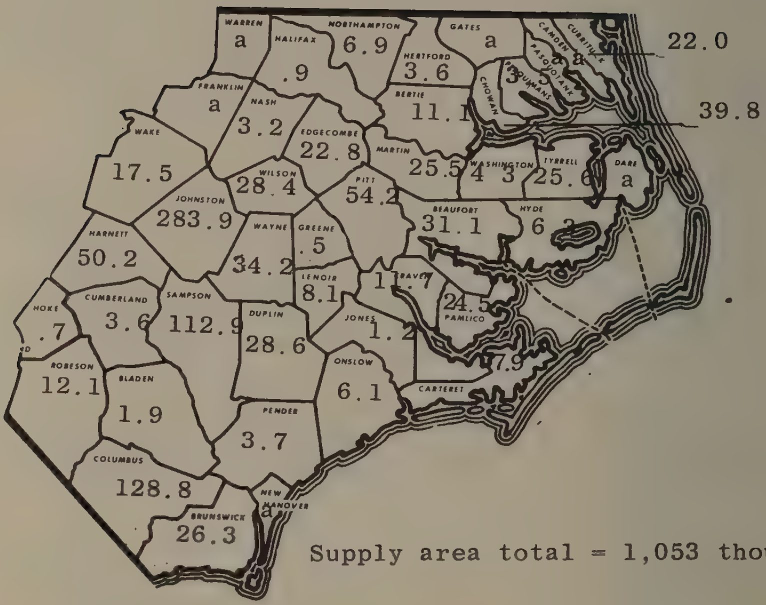
Potential plant locations were selected on the basis of available supplies of processing inputs and locations of existing sweet potato marketing facilities. The location of the 22 plant sites selected for study is illustrated in Figure 2.

The transportation cost table was generated by substituting elements from the distance table, containing mileages from each of the 138 origins to the 22 possible destinations, into the transfer cost function. The transportation costs calculated on the basis of round-trip road miles were presented by Mathia (1962).

The basic data for estimating the processing cost-output relationship were drawn from a processing profitability study conducted by Hammond (1961).

Procedure

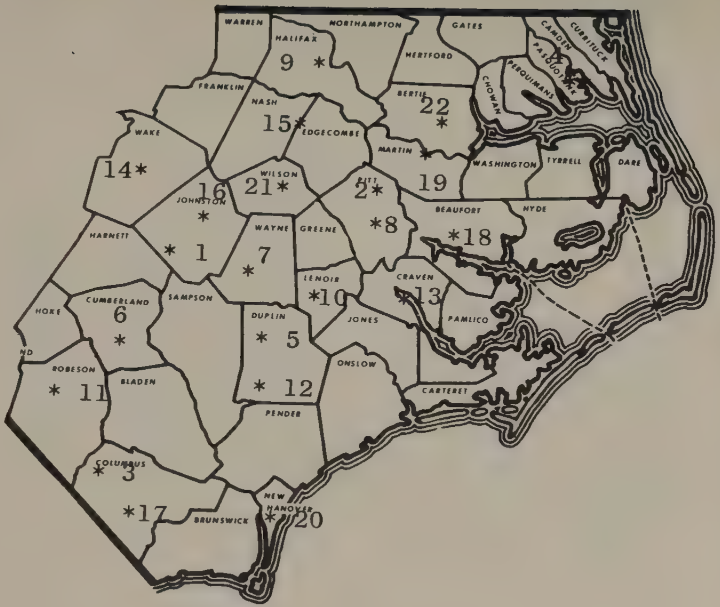
An efficient industry includes the three operations of production, assembly and processing. The relationship among these three variables determines the industry organization which would best serve the interest of both producers and processors. Optimum organization of the sweet potato processing industry is defined as being that specified number, size and location of processing plants which will minimize combined assembly and processing costs, given the pattern of production.



Supply area total = 1,053 thousand cwt.

Figure 1. Commercial sweet potato production in thousand hundredweights in 138 townships by county, 1960

a/Contains no township harvesting 30 acres.



Legend

Number	Location
1	Benson (F)
2	Bethel (F)
3	Chadbourn
4	Elizabeth City
5	Faison (F)
6	Fayetteville
7	Goldsboro
8	Greenville
9	Halifax
10	Kinston
11	Lumberton (P,F)
12	Magnolia (F)
13	New Bern
14	Raleigh
15	Rocky Mount
16	Smithfield
17	Tabor City (P,F)
18	Washington
19	Williamston (P)
20	Wilmington (F)
21	Wilson
22	Windsor

Figure 2. Location of 22 potential sweet potato processing plant sites selected in study area a/

a/Location of existing fresh markets (F) and processing plants (P) in 1960 are indicated.

Thus, minimization of combined assembly and processing costs has been selected as the criterion for evaluating the efficiency of the sweet potato processing industry.

Three important forces which affect the optimum number, size and location of plants are (1) quantities of the raw product which are scattered unevenly throughout the supply area, (2) assembly costs encountered in assembling the raw product and (3) processing costs encountered in changing the form of the raw product. The problem of equilibrating these three forces can be simplified by allowing only two opposing forces to vary at one time. The third force can be evaluated by selecting alternative levels. Assembly costs and processing costs are the two forces which vary with plant numbers and location. The production density pattern is considered to be predetermined although four different levels of output were assumed.

Assume that the positively sloping linear assembly cost function represents the type of function encountered in assembling raw sweet potatoes. What would be the effect on total assembly costs ($\overline{TAC}$) for a given amount of raw material ($\overline{V}$) if the number of plants is increased? The $\overline{TAC}$ function would be expected to decline as the number of plants increases because size of the supply area for particular plants and total distance required for assembly are reduced. This effect is illustrated in Figure 3 where $\overline{TAC}$ represents minimum total assembly costs associated with assembling a fixed volume of raw product.

The effect of number of processing plants on total season processing costs (TSPC) is illustrated in Figure 4. TSPC represents total season processing costs associated with processing a fixed volume (V) of product. The TSPC function for a given amount of raw material would be expected to be horizontal unless economies of scale exist in which case TSPC would increase as the number of plants increases. This type of relationship results from the fact that the minimum costs of establishing and maintaining processing plants vary directly with the number of plants considered providing all plants at all locations use the same production technology.

The summation of these two relationships results in a combined assembly and processing function useful in evaluating the efficiency of the marketing system. The procedure for summing the assembly and processing relationships is presented in Appendix A. The combined cost function (TC) and a hypothetical two-plant solution are presented in Figure 4. The optimum number and location of plants are determined when effects of reduced assembly costs are just offset by countervailing effects of increased processing costs as the number of plants increases.

The minimum assembly cost function provides information as to where the fixed supply of raw potatoes should be shipped

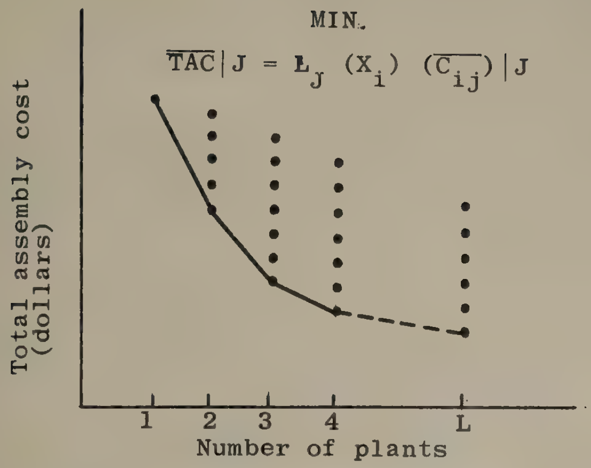


Figure 3. Minimized total assembly costs for fixed volume of raw product

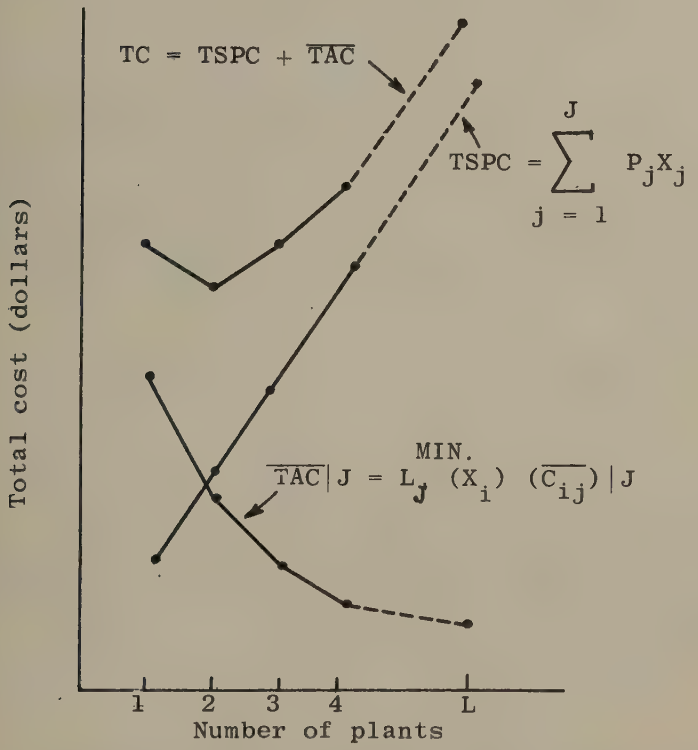


Figure 4. Minimized total assembly and processing plant cost for fixed volume of raw product

by assigning each production origin to the plant which minimizes its assembly costs. This follows from the assumption of equal f.o.b. plant prices.

Assumptions

Several assumptions are used throughout this analysis to determine the number, size and location of sweet potato processing plants which will minimize total assembly and processing costs for the industry.

Raw product market: Raw product price is considered to be $2.00 per hundredweight at all possible plant sites. The net farm price differs among origins because of differing assembly costs.

Finished product market: Price of the finished product is assumed to be equal at all possible plant sites.

Factor prices: Constant and equal factor prices are assumed to exist at all possible plant sites.

Supply origins: Production is considered to be concentrated at one point for each origin. A community center was designated to represent the point of origin in each of the 138 townships.

Potential plant sites: Each of the 22 potential plant sites is assumed to have the transportation network and factor supplies required to support a processing plant.

Finished product distribution: Each plant is assumed to allocate its pack among the four commonly used can sizes in the same relative distribution as the total United States pack in 1958 and 1959 used by Hammond (1961). The distribution of raw product among can sizes is as follows:

Can size	Percent
2 1/2	28
303	18
3 squat	37
10	17

Conversion rate: Conversion rate between the raw product and processed product at 40 percent trim and peel loss was estimated by Hammond (1961) to be 2.59 cases per hundredweight. The details of this conversion procedure are presented by Hammond and King (1962), page 12.

COSTS OF ASSEMBLING SWEET POTATOES

Description of Sweet Potato Assembly Operations

North Carolina sweet potato producers commonly use trucks to assemble the raw product. Size of the truck used depends on such factors as volume of production (bushels per season), rate of output (bushels per hour) and distance from field to plant. All of these factors have to be considered in deriving an assembly cost function suitable for estimating the cost of assembling the raw product.

Customary procedure for assembling sweet potatoes in North Carolina for the fresh market is to load potatoes in bushel baskets directly onto a truck which moves through the field. Canner grade potatoes are loaded on a truck the second trip through the field and transported directly to the processing plant either in bushel baskets or in bulk. Bulk hauling or reusable lugs would appear to be more economical because the cost of loading containers is depreciated over a larger volume of raw sweet potatoes.

Labor requirements for loading a truck vary with size of truck and type of loading facilities. In general, one laborer places the potatoes on the truck, one laborer stacks baskets on the truck and one laborer drives the truck during the loading operations. The truck driver transports the potatoes from the field to the processing plant. The other two laborers involved in loading the potatoes remain in the field. The truck driver assists other laborers located at the plant with the unloading. The total amount of labor which is required to assemble sweet potatoes depends on size of truck, rate of output (bushels per hour) and distance between field and plant. All of these variables are important in determining assembly costs. However, the total costs associated with varying distances traveled will be of primary concern in this study.

Estimation of Assembly Costs

The costs associated with the assembly operations can be separated into two types. The first type is composed of fixed truck expenses such as depreciation, interest on investment, insurance and other miscellaneous expenses. In general, these costs do not vary with use or miles traveled. The second type of expense refers to variable truck expenses such as gasoline, oil, tires, tubes and repairs which depend on the miles traveled. Labor costs would properly be placed in this category, but for convenience labor costs are considered separately.

Estimation of costs for trucks transporting sweet potatoes is complicated by the fact that very few trucks are used solely for hauling sweet potatoes. Sweet potato harvesting and marketing operations usually begin in September and end in February or March. Therefore, less than six months of truck use would be required by the sweet potato enterprise. The truck would be used for other activities the remaining six months of the year. For this reason, only 50 percent of annual fixed costs is charged against the sweet potato operation.

The size of truck selected for computing costs of transporting sweet potatoes is a two-ton truck. Effects of four different sizes of trucks on assembly costs are discussed by Mathia and King (1962). The two-ton truck was selected for consideration because of its adaptability to other activities as well as its suitability for hauling sweet potatoes.

Data used to estimate truck and labor costs were provided by truck sales companies and insurance agents. The economic-engineering approach was used to synthesize these data. This approach is a process of deriving input-output coefficients based on expected requirements and performances which are used to compute costs and returns from productive activities.

Costs of operating a truck for hauling sweet potatoes are affected by the type of driving conditions. In sweet potato assembly operations, two different types of driving conditions are encountered. The first type is where the truck is driven through the field to pick up the baskets of potatoes. The truck is driven very slowly and many stops and starts are made. The second type of driving condition is on-road driving to and from the processing plant. The truck is fully loaded one way to the market but is usually empty coming back to the field. Size of load not only affects the speed but also the costs of operating the truck. The average size of load for which a two-ton truck is registered was estimated by the North Carolina License Bureau to be approximately 5200 pounds net weight.

The two types of driving conditions should be considered in estimating costs of operating the truck. For location analysis, the level of the total assembly cost function does not appear to be as critical as the variability of cost functions among supply origins. This study assumes that all origins located the same distance from the plant have equal per unit assembly costs. The assembly cost function required for location analysis is expressed in terms of average total cost per hundredweight. Total costs associated with moving sweet potatoes from all origins to all destinations are estimated by inserting distances from origins to destinations into the assembly cost function which includes both fixed and variable labor and truck costs.

Estimates of fixed cost items are presented in Table 1. Depreciation and insurance charges make up a very large proportion of total fixed charges. Any allocation of part of these costs to sweet potato marketing activities is highly arbitrary. As a rough approximation one-tenth of the costs of fixed items were allocated to sweet potato hauling or a total of $64 annually. If driven 2000 miles in the hauling operation, the fixed cost would be $.032 per mile.

Table 1. Estimated fixed costs of operating a two-ton truck

Item	Description	Total cost
		(dollars)
Replacement cost	two-ton truck	3,000
Salvage value	two-ton truck	200
Annual depreciation	10-year life	280
Interest[a]	3 percent per year	90
Repairs [a]	1 percent per year	30
Insurance	$50 deductible and 10-20-5 liability	204
Taxes, licenses, fees and misc.[a]	1.2 percent per year	36
Total fixed cost per year		640

[a] Estimated as a percent of replacement cost.

Estimates of variable cost items are presented in Table 2. Gasoline contributed over half of total variable costs. Average variable cost was estimated at $.076 per mile.

Labor costs and rates of assembling sweet potatoes are presented in Table 3. Loading and unloading labor would not be expected to vary with distance. Rate of loading was estimated at 26 hundredweight per man-hour and rate of unloading which includes waiting time by the driver at 27 hundredweight per hour. However, labor involved in transit would vary with the number of miles round trip to the market. The rate at which sweet potatoes are transported was estimated at 1040 hundredweight per hour divided by miles hauled round trip. The estimate of labor requirements for loading was 120 man-minutes or $2.56 per load. Waiting and unloading were estimated at 115 man-minutes or $2.58 per load. Costs of waiting and unloading are more expensive for the 115 man-minutes than the 120 man-minutes required to load because of the higher hourly wages of the truck driver. Labor requirement in transit was estimated to be $.068 per mile. This is based on a $1.35 per hour wage and a 20-mile per hour transit speed.

Table 2. Estimated variable costs associated with assembling sweet potatoes with a two-ton truck

Item	Description	Average cost
		(dollars per mile)
Gasoline	6 mi. per gal. $.30 per gal.	.050
Oil, grease filters, etc.		.011
Tires and tubes	20,000-mile life	.010
Misc. repairs		.005
Total		.076

The Cost-Distance Relationship

The cost-distance relationship can be expressed in terms of either road or air miles. The assembly cost function in terms of road miles would appear to be more meaningful to sweet potato processors and producers. The cost-distance relationship in terms of road miles for a two-ton truck using the estimated rates of assembly stated above is as follows:

$$C = \$5.14 + \$.176D_R \tag{2.1}$$

where C = total assembly costs in dollars per load and

D_R = distance in road miles, round trip.

Average cost per hundredweight hauled can be estimated with a modification of this cost-distance function in which Equation (2.1) is divided by the average load size in hundredweight (V) in the following manner:

$$C' = \frac{\$5.14 + \$.176D_R}{V} \tag{2.2}$$

where C' = average cost per hundredweight hauled. When V is 52 hundredweight, Equation (2.2) takes on the following form:

$$C' = \$.099 + \$.0034D_R \tag{2.3}$$

It is assumed that average cost per hundredweight increases at a constant rate as distance hauled increases. When the distance from origin to destination is zero, average cost per hundredweight is $.099 which represents the fixed labor costs involved in assembling sweet potatoes.

Table 3. Estimated labor costs associated with assembling sweet potatoes with a two-ton truck

Item	Description	Rate	Time required per 5200-pound load	Price	Cost
		(cwt./man-hour)	(man-minutes)	(dollars/hour)	(dollars/load)
Loading	Place baskets on truck	78	40	1.25	.83
	Stack baskets on truck	78	40	1.25	.83
	Drive truck	78	40	1.35	.90
	Total	26	120	-	2.56
Waiting and unloading	Driver	27	115	1.35	2.58
			(man-minutes/mile)		(dollars/mile)
Transit	Driver	$\frac{1040}{\text{miles}}$[a]	3[b]	1.35	.068

[a] Depends on round-trip distance from origin to destination.
[b] Assumes an average on-road speed of 20 miles per hour.

The assembly cost function is calculated on the basis of road miles. Computing actual distance in road miles from each origin to every possible destination is more difficult than determining the distance in air miles because of the many possible routes which can be taken. For this reason, a distance matrix composed of air miles from each origin to every destination is computed.[1] The assembly cost function, which is calculated on the basis of road miles, is adjusted upward by approximately 19 percent to allow for the difference in miles between road and air travel. The relationship is:

$$D_R = 1.19D_A \qquad (2.4)$$

where

D_R = distance in road miles,

D_A = distance in air miles.

Regression Equation (2.4) was computed from 192 observations of road and air miles based on a sample of 16 origins and 12 destinations located in the supply area. Although Equation (2.4) may not represent a precise conversion for all other supply areas, it should be a close enough approximation to make the results of this location analysis applicable to their long-run planning problems.

COSTS OF SWEET POTATO PROCESSING

Assembly costs decline as plant numbers increase and therefore tend to increase the optimum number and reduce the optimum size of plants. On the other hand, processing costs tend to reduce the optimum number and increase the optimum size of plants when there are economies to scale in processing operations. Economies to scale in processing result from spreading over larger volumes the minimum costs of establishing and maintaining a processing plant. The minimum costs to establish and maintain a plant are an important determinant in location analysis.

The purpose of this part of the report is to develop a generalized method for estimating costs of processing sweet potatoes in plants operated at varying levels of output. Processing costs are minimized for each level of output by deriving an estimating equation based on optimum rates of output and lengths of season.

---

[1] The procedure used in determining the distance table was to locate each origin and destination by latitude and longitude, and with the use of trigonometric functions, distance was computed. A program which was obtained through correspondence with Fred Davis, A. D. Seale, Jr. and T. E. Tramel at Mississippi State University permitted this operation to be carried out on the high speed computer. The transportation cost matrix which represents distance round trip times assembly cost per mile round trip was also computed in the same operation.

The basic processing cost data used in this study were drawn from a previous study of sweet potato processing costs conducted by Hammond (1961). The data required some refinements in order to estimate continuous cost equations. The major refinements involved converting from cost-input to cost-output relationships and allocating the investment in durable goods to selected time periods. A discussion of these refinements along with a summary of these basic data was presented by Mathia (1962).

The important variables affecting total season processing cost (TSPC) are rate of plant operation, length of operating season, percent trim and peel loss, percent of rated capacity and length of planning horizon. For long-run planning purposes, it would seem desirable to plan a processing industry which would operate at near full capacity. Therefore the TSPC functions are based on the assumption of full capacity operations.

Total Season Processing Costs

The continuous processing cost equation assuming a 10-year planning horizon fitted by least squares regression to the data for the four model plants described by Hammond (1961) is as follows:

$$\text{TSPC} = 30{,}560.00 + 26.73H + 173.50R + 226.50T + 2.324HR + .02662HRT \tag{3.1}$$

where

TSPC = total season processing costs,

H = hours of operation per season,

R = rate of operation in cases per hour, and

T = percent trim and peel loss.

The signs and relative magnitudes of the coefficients of Equation (3.1) appear reasonable. The constant is a mixed term including "true" annual fixed costs plus operating costs not associated with the variables H, R and T. Estimated TSPC for varying rates of output and lengths of season are presented in Table 4. Average trim and peel loss was found to be 42 percent in existing plants in North Carolina and Louisiana by Hammond (1961). Thus, 40 percent trim and peel level was selected to analyze economies of location in this

Table 4. Estimated total season processing cost for operating a model plant at varying length of season and rate of output assuming a 40 percent trim and peel loss, 100 percent rated capacity, and a 10-year planning period for durable equipment [a]

Length of season	Rate of output (cases per hour) [b]			
	259	518	777	1,036
(hours)	(thousand dollars per season)			
600	627.2	1,198.8	1,770.4	2,341.9
800	808.1	1,555.2	2,302.3	3,049.4
1000	989.0	1,911.7	2,834.3	3,757.0
1200	1,169.9	2,268.1	3,366.3	4,464.5
1400	1,350.8	2,624.5	3,898.3	5,172.0
1600	1,531.7	2,981.0	4,430.2	5,879.5

[a] Computed from Equation (3.1).

[b] These rates correspond to plants operating at 10,20, 30 and 40 thousand pounds of raw product per hour.

study. Note again that Hammond's can size distribution and conversion rates are used throughout the analysis which follows. Typical operating schedules suggested by Hammond are also used (Table 5).

Equation (3.1) is based on a price of $2.00 per hundredweight for raw product delivered to the plant. The TSPC estimating equation can be adjusted for other raw product prices with little difficulty. Effects of changes in raw product price on TSPC are presented in Table 6. For location analysis, changes in the level of raw product price are not as critical as changes in net farm price which occur as alternative plant location combinations are considered. These changes in location enable some processing plants to extend their raw product supply area at the expense of other locations.

Since there is a direct relationship between rate of output and length of season in processing a fixed quantity of raw product, a decision based on economic considerations has to be made regarding the substitution rate between these two variables. Equation (3.1) is used to estimate a relationship of TSPC which represents the optimum rates of output and lengths of season for varying levels of output. TSPC as a function of length of season is presented in Figure 5. TSPC increases directly with the length of season. The shift variable in this particular case is rate of output. For a specified length of season, the TSPC functions, at a length of season below 600 hours, represent a linear extension of the processing cost data.

Table 5. Typical operating schedules for sweet potato canning plants

Shift	Length of season (hours)					
	600	800	1000	1200	1400	1600
First shift:						
Hours/week	40	40	40	40	48	50
Weeks/year	15	15	15	15	15	16
Second shift:						
Hours/week	--	40	40	40	45	50
Weeks/year	--	5	10	15	15	16

Table 6. Effects of raw product price on total season processing costs assuming a 40 percent trim and peel loss, 1000 hours of operation per season and a 10-year planning horizon [a/]

Output [b/]	Raw product price (dollars per cwt.)		
	\$1.00	\$2.00	\$3.00
(cases per season)	(thousand dollars per season)		
100,000	384.0	422.6	461.1
200,000	697.6	774.8	852.0
300,000	1,019.2	1,135.0	1,250.9

[a/] Based on equation (3.1) less $\frac{1}{K}$ (2.00 - P_i is new raw product price and K is the number of cases packed per hundredweight of raw product.

[b/] Rate of operation varies directly with cases of output per season.

The TSPC as a function of rate of output is presented in Figure 6. The shift variable in this case is the length of season. With any specified rate of output, the TSPC shifts upward as the length of season increases.

With a 40 percent trim and peel loss, some particular rate of output and length of season minimize the costs of processing any particular volume of output. Different rates of output and lengths of season are required to minimize processing costs of each plant depending on volume of output processed. A processing cost equation required to estimate the minimum TSPC for all volumes of output is derived from Equation (3.1). The new TSPC relationship estimates the minimum processing costs for all levels of output by choosing the optimum rate of output and length of season.

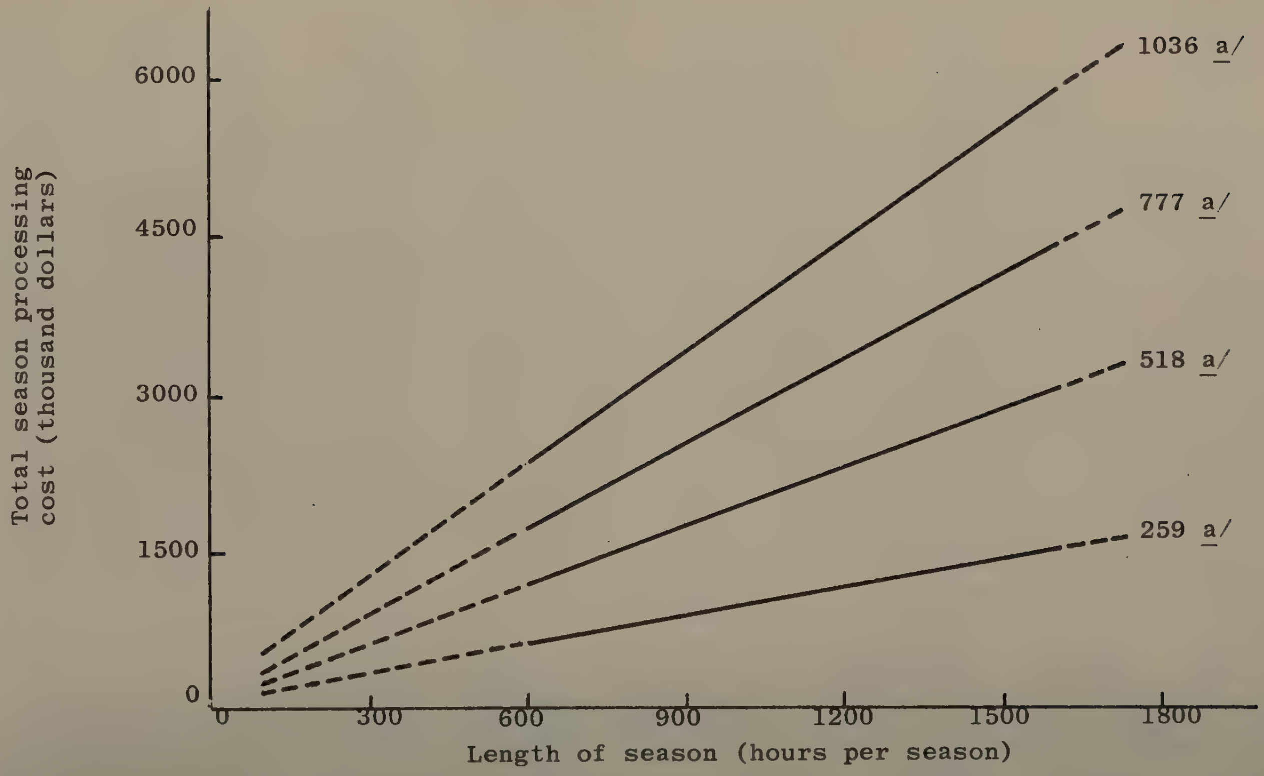


Figure 5. Estimated total cost for operating varying lengths of season and rates of output assuming a 40 percent trim and peel loss, 100 percent rated capacity and a 10-year planning period for durable equipment as computed from Equation (3.1)

a/Refers to rate of output in cases per hour.

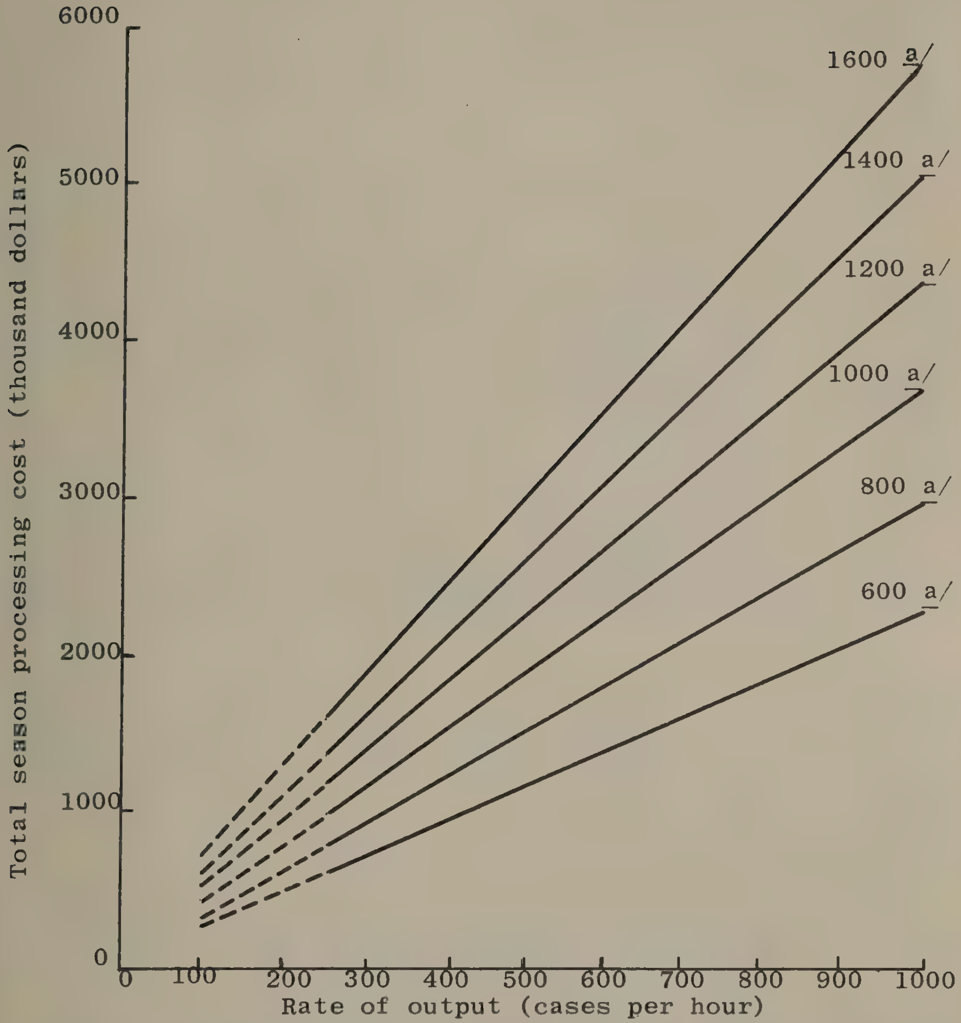


Figure 6. Estimated total cost per season for operating at varying rates of output and lengths of season assuming a 40 percent trim and peel loss, 100 percent rated capacity and a 10-year planning period for durable equipment as computed from Equation (3.1)

a/Refers to hours per season.

A procedure for determining the optimum rates of output and lengths of season was used to estimate minimum processing costs for varying volumes processed. The procedure and data were summarized in a study conducted by Mathia (1962). A linear total cost equation fitted by least squares regression to these data is as follows:

(3.2) $$TSPC^* = \$82,781.00 + \$3.4906V$$

where

$TSPC^*$ = minimum total season processing costs, and

V = volume of output in cases per season.

The TSPC as a function of volume of output using the optimum rate of output and length of season is presented in Figure 7. The intercept value of $82,781 represents an estimate of the minimum annual cost of establishing and maintaining a processing plant. This minimum value will be used in determining the number of plants required to minimize combined assembly and processing costs.

Average Processing Costs

The equation for estimating average processing costs can be derived by modifying the TSPC functions as follows:

(3.3)

$$APC = \frac{30,560.00 + 26.73H + 173.50R + 226.50T + 2.324HR + .02662HRT}{V}$$

where

APC = average cost of processing sweet potatoes in dollars per case, and

V = volume of sweet potatoes processed in cases per season, derived by multiplying the rate of output (R) times the length of season (H).

The effects of rate of output and length of season on processing cost per case are shown in Table 7. For a plant having a capacity of 259 cases of output per hour, average processing costs vary from $4.04 at 600 hours to $3.70 at 1600 hours of operation. This is a difference of $.34 per case which represents over an 8 percent decrease. Average costs are also sensitive to a changing rate of output. For example, assuming a 1000-hour season, average cost would decline from $3.82 at 259 cases per hour to $3.63 at 1036 cases per hour. This represents a decrease of $.19 or about 5 percent.

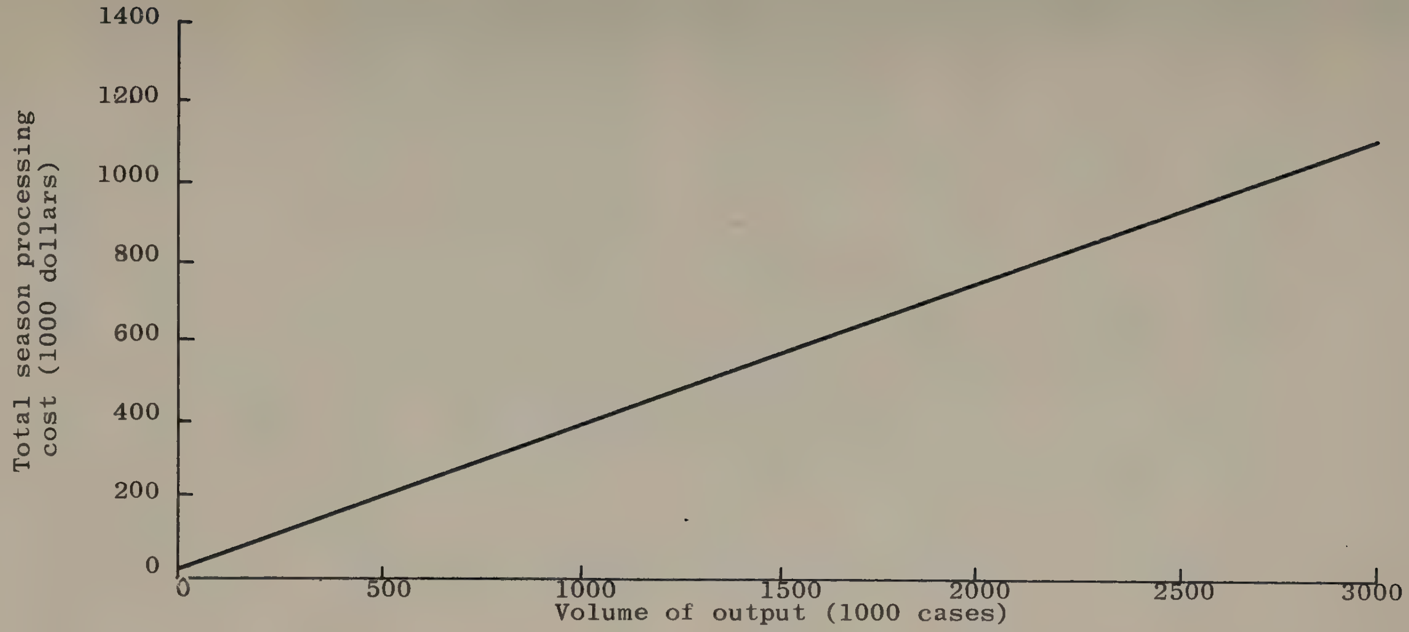


Figure 7. Relationship between total season processing costs and volume of output with optimum rate of output and length of season a/

a/Based on Equation (3.2).

Table 7. Estimated average cost for operating at varying lengths of season and rates of output assuming a 40 percent trim and peel loss, 100 percent rated capacity and 10-year planning period for durable equipment a/

Length of season	Rate of output (cases per hour) b/			
	259	518	777	1036
(hours)	(dollars per case)			
600	4.40	3.86	3.80	3.77
800	3.90	3.75	3.70	3.68
1000	3.82	3.69	3.65	3.63
1200	3.76	3.65	3.61	3.59
1400	3.73	3.62	3.58	3.57
1600	3.70	3.60	3.56	3.55

a/Based on Equation (3.3).

b/These rates correspond to plants operating at 10,20, 30 and 40 thousand pounds of raw product per hour.

Using Equation (3.3), effects of rate of output and length of season on processing costs can be demonstrated. For example, effects of rate of output on average costs are illustrated in Figure 8. The shift variable in this case is length of season. The reduction in average cost at any particular rate of output becomes less as length of season increases. Also, average cost changes very little with changes in rate of output above 700 cases per hour.

Effects of length of season on average processing costs can be observed in Figure 9 when rate of output is considered as the shift variable. The large economies of size yielded when rate of output is increased from 259 cases to 518 cases are represented by the divergence of the respective functions. Rates of output greater than 777 cases per hour have little effect on average costs as indicated by the relatively small divergence between the 777 and 1036 cases per hour curves.

Average costs are less for the same volume when the optimum rates of output and lengths of season for all volumes are used. If the average cost equation is derived from the total cost Equation (3.2), the following equation results:

$$(3.4) \qquad APC^* = \frac{\$82,781.00}{V} + \$3.4906$$

where

APC* = minimum average processing cost in dollars per case, and

V = volume of output in cases per season.

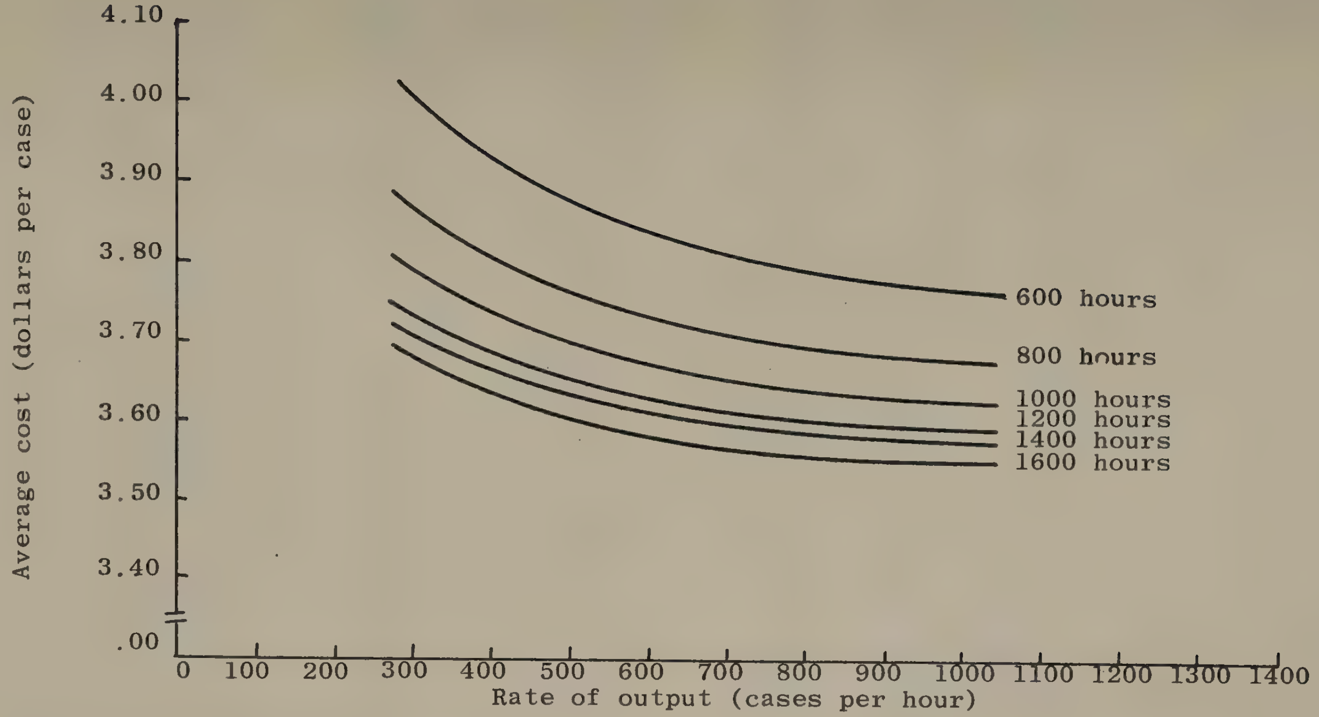


Figure 8. Estimated average cost for operating at varying rates of output and selected lengths of season assuming a 40 percent trim and peel loss, 100 percent rated capacity and a 10-year planning period for durable equipment a/

a/Based on Equation (3.3).

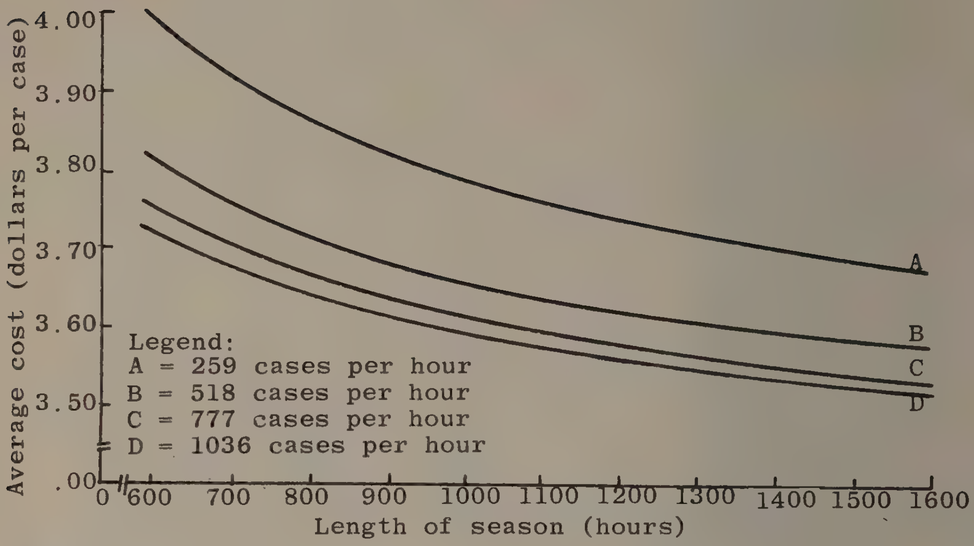


Figure 9. Estimated average cost for operating at varying lengths of season and rates of output assuming a 40 percent trim and peel loss, 100 percent rated capacity and a 10-year planning period for durable equipment a/

a/Based on Equation (3.3).

The average processing cost relationship calculated on the basis of Equation (3.4) is presented in Figure 10. Average processing costs decline very little beyond the output of approximately 1,500,000 cases per year.

Marginal Processing Costs

The method of determining marginal cost with respect to the rate of output dimension from Equation (3.2) is to take the derivative of TSPC* with respect to the rate of output as follows:

$$\frac{TSPC^*}{V} = \$3.4906$$

Thus, marginal costs associated with Equation (3.2) are about $3.49. The relationship of marginal costs to average costs using Equation (3.2) was presented in Figure 10. Average costs approach marginal costs at very large outputs. In fact, average costs are greater than marginal costs by less than $.02 per case at an output of 2 million or more cases per season.

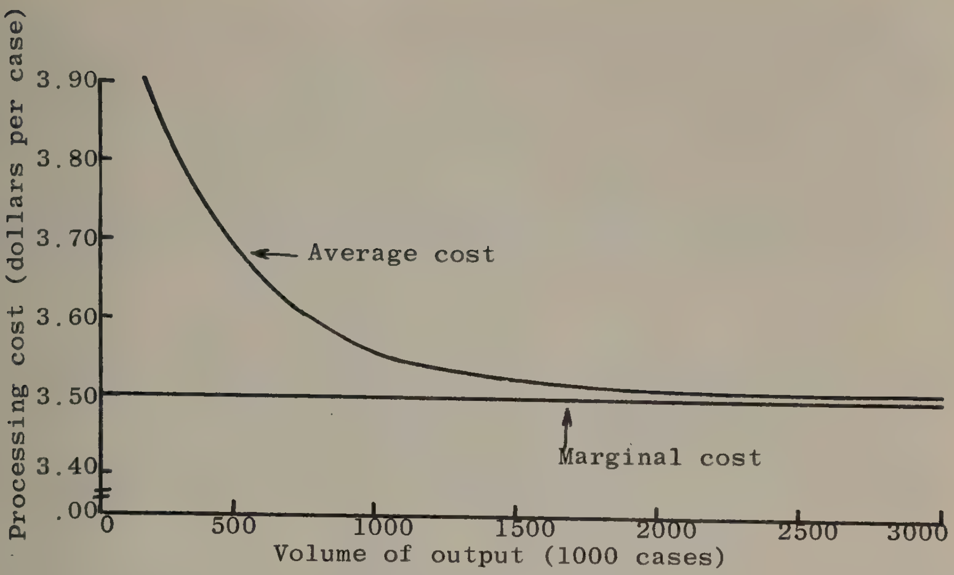


Figure 10. Relationship between average and marginal processing costs and volume of output with optimum combinations of rate of output and length of season a/

a/Based on Equations (3.2) and (3.4).

RELATIONSHIP BETWEEN PLANT NUMBERS AND COSTS

In preceding sections of this report, relationships describing costs of assembly and processing sweet potatoes were presented. In this section of the report, the relationship between these costs and the number of plants in eastern North Carolina is examined. A description of the density of sweet potatoes is followed by a discussion of the relationships between level of output and assembly, processing and combined costs.

Volume and Density of Production

Volume of production available for processing fluctuates from year to year. Factors affecting the volume available for processing are demand and supply conditions for fresh market green and cured sweet potatoes and the price offered by processors for potatoes. In this study, no effort was made to predict the pattern of change in these volume-determining factors.

However, to illustrate the effects of volume on optimum number, size and location of plants, four levels of sweet potato supply were considered to be available for processing. These four volumes were selected by assuming that 10, 20, 30 and 40 percent of total commercial sweet potato production in the area were available for processing annually. The 20 percent level of production was selected to illustrate the procedure used in determining the optimum number, size and location of plants since approximately 20 percent of total production is composed of canner-size potatoes for whole pack.

The year 1960 was selected to represent the level and density of production since this was the most recent year for which township data were available. Total commercial production in the 138 sweet potato producing townships studied was 1,053,420 hundredweight. Production data by township are available in Mathia (1962), pages 112-116. The volumes available for processing in hundredweight of green potatoes and the equivalent cases of processed sweet potatoes for each of the four supply levels are shown below.

Proportion of 1960 commercial production processed (percent)	Equivalent raw product processed (hundredweight)	Equivalent finished product processed a/ (cases)
10	105,342	272,836
20	210,684	545,672
30	316,026	818,507
40	421,368	1,091,343

a/Assumes a conversion rate of 2.59 cases per hundredweight for 40 percent trim and peel loss and U. S. average can size distribution.

Unlike volume of production, relative density is stable from season to season. For this reason, only one production density pattern is considered in determining optimum number, size and location of processing plants. Three relatively large concentrations of production can be seen in Figure 1 where data were aggregated within counties. However, township data were used to determine the optimum number, size and location of plants. Certain counties have no commercial production because townships with less than 30 acres harvested were eliminated.

The largest concentration of production was located in Johnston, Sampson and Harnett counties. Production in these three counties was 447,030 hundredweight which represents approximately 42.4 percent of commercial production produced in the 43-county supply area. The second concentration of production was located in Columbus and Brunswick counties. Production in these two counties was 155,084 hundredweight or about 14.7 percent of total commercial production. The third area of concentrated production was Martin, Pitt and Beaufort counties. These three counties produced 110,740 hundredweight which represents 10.5 percent of the total commercial production in the supply area considered.

These three concentrations accounted for 712,854 of the 1,053,421 hundredweight considered as commercial production within the 43-county supply area. This quantity represents 67.7 percent of the total quantity in the supply area.

Assembly Costs

The minimum assembly cost with respect to number of plants is of primary concern in determining the optimum number, size and location of processing plants. The relationship between assembly costs and number of plants is based on the premise that f.o.b. plant raw product price is independent of number, size and location of plants.

To estimate the minimum costs of assembling sweet potatoes for varying numbers of plants is a sizeable computational task. For example, if 22 possible plant sites are considered and one site is to be selected, the minimum assembly cost is selected from 22 total assembly cost values. This is done by assigning the total volume to each of the 22 plants in succession and selecting the plant site representing the minimum costs.

When considering more than one plant, all possible combinations of plants have to be considered by assigning the production at each supply origin among plants so as to obtain minimum total assembly costs.[2]

The effect of number of plants on assembly cost is presented in Table 8. For example, the total cost to assemble the raw product equivalent of 545,672 cases of output decreases from $108,987 with one plant to $77,314 per season with two plants. A 29 percent decrease in assembly costs is achieved when the second plant is added. When the best sites for four plants are considered, total assembly costs are $53,228 per season or 51 percent less than the one-plant solution. Total assembly costs increase in proportion to increases in area of output. As volume of output doubles from 545,672 cases to 1,091,343 cases per season, total assembly costs double from $108,987 to $217,975 per season when considering one plant.

---

[2] A program was written for the Univac 1105 high speed computer by the author and Dr. Tom Donnelly, Professor of Mathematics at the University of North Carolina, which computed total assembly costs for all possible combinations of locations for varying numbers of plants. The location or combination of locations associated with minimum assembly costs was selected for varying numbers of plants. Additional information concerning the program can be obtained through correspondence with the Dept. of Agr. Econ., N. C. State College.

Table 8. The relationship between number of plants and total assembly costs at four levels of output

Number of plants	Total assembly cost Area output a/ (cases per season) 272,836	 545,672	 818,507	 1,091,343	Percent change b/
	(dollars/season)				(percent)
1	54,494	108,987	163,481	217,975	base
2	38,657	77,314	115,971	154,628	- 29.1
3	29,209	58,418	87,627	116,836	- 46.4
4	26,614	53,228	79,842	106,456	- 51.2

a/These volumes represent 10, 20, 30 and 40 percent of 1960 commercial production.

b/Relative changes are independent of level of output.

The changes in assembly costs using a one-plant industry at the 20 percent output level as a base are presented in Table 9. The largest decrease in assembly costs occurs between one and two plants as indicated by the $31,673 reduction at the 545,672 cases per season output. The change from three to four plants at the same volume of output decreases assembly costs by $5,190.

Average cost of assembly is independent of volume of output because proportional changes in each township have been assumed. Average assembly costs decrease at a decreasing rate when additional plants are considered. Assembly costs decrease $.06 from $.20 to $.14 per case when the second plant is introduced. The change in average assembly costs from three to four plants is less than $.01 per case. Very little reduction in total assembly costs results when more than four plants are considered.

The flatness of the total assembly cost relationship when more than two plants are considered is demonstrated in Figure 11. Unlike the total season processing cost relationship, the assembly cost relationships are not linear with respect to either number of plants or volume of output. The nonlinear relationship of total assembly costs with respect to number of plants is due mainly to the nonproportional manner in which a total supply area is divided as more plants are added. The nonlinear relationship between assembly costs and volume of output results from the uneven density pattern of production in eastern North Carolina.

A comparison of the decrease in total assembly costs with the increase in total processing costs as more plants are added provides the basis for determining the optimum number, size and location of processing plants. As discussed earlier, the largest number of plants for which the decrease in assembly costs is equal to or greater than the increase in processing costs represents the minimum combined cost solution.

Table 9. Relationship between number of plants, change in total assembly costs, average assembly cost per case and average assembly cost per hundredweight of raw product equivalent

Number of plants	Total assembly cost a/	Average assembly cost b/	
		Per case packed	Per cwt. raw product
		(dollars)	
1 (base)	108,987	0.200	0.518
2	- 31,673	0.142	0.368
3	- 50,569	0.107	0.277
4	- 55,759	0.098	0.254

a/Based on area output of 545,672 cases per season representing 20 percent of 1960 commercial production.

b/Average assembly costs are independent of level of area output, assuming location of production is unchanged.

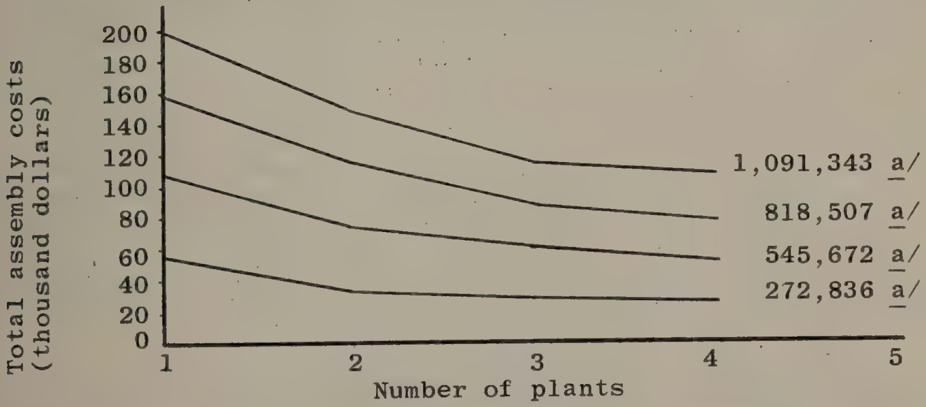


Figure 11. The relationship between total assembly costs and number of plants at four levels of output

a/Refers to cases of sweet potatoes processed per season.

Processing Costs

The assumption of constant and equal marginal costs of processing in all plants discussed earlier in this report simplifies the problem of deriving a processing cost relationship with respect to plant numbers. This assumption concerning marginal costs makes it possible to state the relationship between total season processing costs and number of plants by the following expression:

$$\text{(4.1)} \qquad TSPC = bV + aN$$

where

TSPC = total season processing costs,

b = marginal cost per case of processing sweet potatoes,

V = total volume to be processed in cases per season,

a = minimum season cost of establishing and maintaining a processing plant, and

N = number of plants in operation.

Appropriate values of V and N were substituted in Equation (4.1) to derive each TSPC using the parameters of TSPC Equation (3.2). The relationship between processing costs and plant numbers is presented in Table 10.

An example will clarify how Equation (4.1) is used. If we assume that N = 4, V = 545,672 cases and that the parameters a = $82,781 and b = $3.4906 as provided by TSPC Equation (3.2) are used, then TSPC = $3.4906 (545,672) + $82,781(4) = $2,235,847. The TSPC of any level of production and number of plants is determined in a similar manner. TSPC increases $82,781 for each additional plant.

For the 545,672 cases per season volume of production, TSPC increased from $1,987,504 with one plant to $2,235,847 for four plants. The change in TSPC from one to four plants is about 12 percent. The relative change in TSPC decreases as volume of output is increased. For example, TSPC changes from $3,892,223 with one plant to $4,140,566 with four plants when considering the 1,091,343 cases per season volume which represents about a 6 percent change in TSPC.

The increase in processing costs as number of plants increase is further illustrated by average costs. For the volume of 545,672 cases per season, average costs increase by $.15 per case for each additional plant. Thus, the cost of processing a given volume in four plants is about $.45 per case more than processing the same volume in one plant.

Table 10. The relationship between number of plants, total season processing costs and average processing costs at four levels of output

Number of plants	Area output a/ (cases per season)			
	272,836	545,672	818,507	1,091,343
	Total season processing costs (dollars per season)b/			
1	1,035,142	1,987,504	2,939,862	3,892,223
2	1,117,923	2,070,285	3,022,643	3,975,004
3	1,200,704	2,153,066	3,105,424	4,057,785
4	1,283,485	2,235,847	3,188,205	4,140,566
	Average processing costs (dollars per case)			
1	3.794	3.642	3.591	3.566
2	4.097	3.794	3.693	3.642
3	4.401	3.946	3.794	3.718
4	4.704	4.097	3.895	3.794

a/These volumes represent 10, 20, 30 and 40 percent of 1960 commercial production.

b/Note that processing costs increase by $82,781 per additional plant. (Based on Equation 4.1.)

Combined Costs

The final step in determining the optimum number, size and location of plants involves estimating total assembly and processing costs for varying numbers of plants. The combined cost function represents a summation of the costs of assembly and processing for given volumes of output in varying numbers of plants, and includes all the assumptions underlying both cost relationships discussed earlier.

In general, the combined cost function with respect to numbers of plants decreases as long as the decrease in assembly costs is greater than the increase in processing costs. When the rates of change of the two relationships are equal, combined cost is a minimum. The combined cost function increases when the increase in processing costs is greater than the decrease in assembly costs.

The relationship between combined cost and numbers of sweet potato processing plants in eastern North Carolina is presented in Table 11. For a season output of 545,672 cases, total combined costs increase from $2,096,491 with one plant to $2,147,599 per season with two plants. This represents an increase in combined costs of 2.4 percent. The change from one to four plants represents a 9.2 percent increase in combined costs.

Table 11. The relationship between number of plants, total combined costs and average combined costs at four levels of output

Number of plants	Area of output a/ (cases per season)			
	272,836	545,672	818,507	1,091,343
	Total combined costs (dollars per season) b/			
1	1,089,636	2,096,491	3,103,343	4,110,198
2	1,156,580	2,147,599	3,138,614	4,129,632
3	1,229,913	2,211,484	3,193,051	4,174,621
4	1,310,099	2,289,075	3,268,047	4,247,022
	Average combined costs (dollars per case)			
1	3.994	3.842	3.791	3.766
2	4.239	3.936	3.835	3.784
3	4.508	4.053	3.901	3.825
4	4.802	4.195	3.993	3.892

a/These volumes represent 10, 20, 30, and 40 percent of 1960 commercial production.

b/Total of entries in Table 8 and Table 10.

With an output of 545,672 cases per season, average combined costs increase about $.10 per case when the second plant is added. At the output of 1,091,343 cases per season, the difference in average combined costs is only $.01 between one and two plants. Beyond two plants, differences increase when additional plants are considered.

The general relationship of the combined cost functions is illustrated in Figure 12. The total combined cost functions do not decrease for any volume of output. The functions increase for all plant numbers greater than one. An analysis of the combined cost function provides information concerning the optimum solution in the sequence of plant numbers, plant locations and plant sizes. This is the order of events in which the optimum solution will be discussed in this report.

THE OPTIMUM NUMBER, SIZE AND LOCATION OF PROCESSING PLANTS

The three variables of production density and volume, assembly costs and processing costs have been integrated in sequence to derive a combined cost relationship. This combined cost relationship provides information regarding the optimum number, size and location of plants under various conditions. Comparisons with the cost of solutions other than the optimum can also be made.

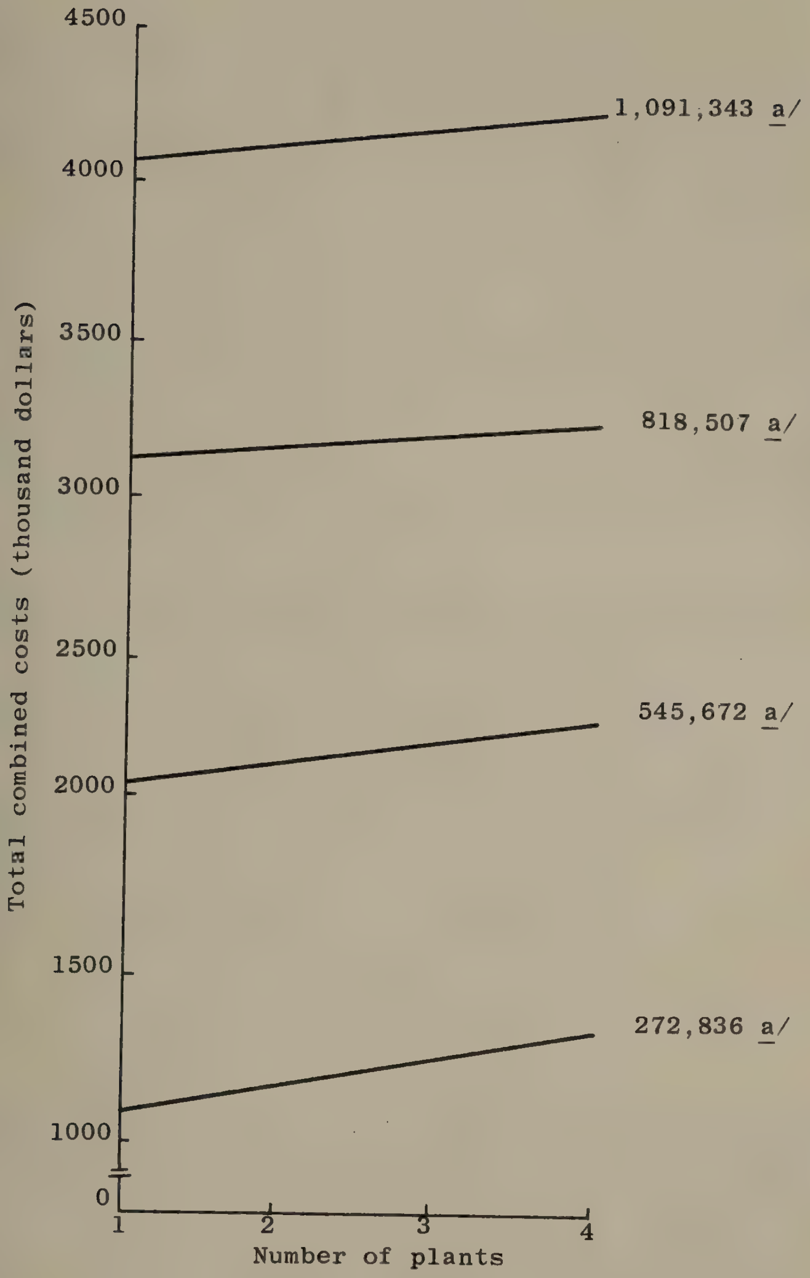


Figure 12. The relationship of combined costs to number of plants at four levels of area output

a/Refers to cases of sweet potatoes processed per year.

Number of Plants

With the 1960 production pattern, a single specialized processing plant represents the optimum number of plants for all four levels of area output. This solution is derived by selecting the number of plants representing the minimum cost at each volume of output in Table 11. For example, the season cost of $2,096,491 to assemble and process 545,672 cases in one plant is lower than for any other number of plants.

There are certain conditions under which more than one plant would represent the optimum solution. These include (1) an increase in the volume of output to be processed, (2) a reduction in the minimum cost of establishing and maintaining a processing plant either through reducing one or more processing-input prices or possibly introducing multiple-product lines and (3) an increase in the cost of assembling relative to the cost of processing sweet potatoes. Increasing the volume of output is of particular concern in this part of the report. The second and third variables will be considered in a later part of the report since they tend to affect location more than number of plants.

One set of conditions under which two plants would represent the optimum number of plants is the following:

2 plants optimum if:

Minimum quantity processed		1,426,130	cases
Minimum quantity processed as related to 1960 area production		52.3	percent
Total costs:	Processing	$5,144,250	per season
	Assembly	202,062	per season
	Combined	$5,346,312	per season
Average costs:	Processing	$ 3.61	per case
	Assembly	.14	per case
	Combined	$ 3.75	per case

The area output required to make a second plant profitable represents 52.3 percent of the total 1960 commercial production. This volume is derived by computing the volume of output at which the change in assembly costs equals the cost of adding a processing plant. At the 1,426,130 case-per-season output, the change in assembly costs equals the change in processing costs when the second plant is added. Therefore, average combined costs would be equal with either a one-plant or a two-plant industry at this level of output. However, average processing costs would be less than the $3.61 and assembly costs would be more than $.14 per case when comparing one plant with two plants. For example, a one-plant industry could assemble and process the 1,426,130 cases for $.20 and

$3.55 per case, respectively. This means that assembly costs increase by $.06 and processing costs decrease by $.06 when comparing the one- and two-plant industries.

The conditions necessary for three plants to be the optimum number can be determined by computing the output which yields equal combined costs with either a two- or three-plant industry. The conditions are as follows:

3 plants optimum if:

Minimum quantity processed		2,390,520	cases
Minimum quantity processed as related to 1960 area production		87.6	percent
Total costs:	Processing	$8,592,692	per season
	Assembly	255,922	per season
	Combined	$8,848,614	per season
Average costs:	Processing	$ 3.59	per case
	Assembly	.11	per case
	Combined	$ 3.70	per case

For a three-plant optimum solution, output must increase to 2,390,520 cases or more which represents 87.6 percent of the total 1960 area production. With the volume required for a three-plant industry, average costs were $.05 less than the costs associated with the minimum quantity required to bring in two plants as discussed above. Average combined costs to assemble and process 2,390,520 cases per season output are the same in both the two- and three-plant industries. However, the ratio of assembly and processing costs would be different.

The conditions necessary for an optimum four-plant industry are as follows:

4 plants optimum if:

Minimum quantity processed		8,703,520	cases
Minimum quantity processed as related to 1960 area production		319.0	percent
Total costs:	Processing	$30,711,631	per season
	Assembly	848,988	per season
	Combined	$31,560,619	per season
Average costs:	Processing	$ 3.53	per case
	Assembly	.10	per case
	Combined	$ 3.63	per case

The minimum quantity of potatoes required to have a four-plant optimum solution represents a very large increase over the quantity required for the two- or three-plant optimum solutions. Three plants were optimum with 2,390,520 cases compared to 8,703,520 cases for a 4-plant solution. This represents a 264 percent increase for four plants compared to three plants.

The reason for the very large change in quantity for four plants is due mainly to the nature of the assembly cost relationship. At 8,592,692 cases, average assembly costs decline by less than $.01 with four plants compared with assembling the same volume in an optimum three-plant industry.

For four plants to be the optimum number, volume of output would have to increase by 219 percent over the 1960 commercial production if the entire crop went to processors. However, if the area output required to have a 4-plant solution could be obtained, the average costs of processing would be at a low of $3.63 per case.

Location of Plants

Optimum locations of plants were selected from 22 possible plant sites scattered throughout the supply area. In this study, all possible plant sites were considered to have equal processing-input prices including the price of green sweet potatoes. Therefore, assembly costs and the production density pattern are the only factors determining optimum locations of plants.

In general, there is only one plant site which represents the single best solution for a given level of output and density pattern. The location of plants is specified in the process of determining the optimum number of plants. However, optimum locations of plants can be found for any given number of plants. Choosing optimum locations once the optimum number has been determined may be as critical as choosing the optimum number of plants. The purpose of this section is to describe the optimum location for the one plant and to estimate the costs associated with locating at alternative sites.

Comparison of Optimum Plant Locations. The optimum location for one plant can be determined from Table 12. The twenty-two possible plant sites are listed in order of combined assembly and processing costs. Faison, which represented the best location in terms of lowest combined costs, was used as base with area output of 545,672 cases per season, total combined costs were $2,096,492 per season and average combined costs were $3.84 per case. Faison is located within a triangle which connects the three production concentrations discussed earlier. Duplin, the county in which Faison is located, borders the heaviest concentrated area as indicated in Figure 13.

Table 12. Comparison of alternative plant sites for a single plant assuming an output of 545,672 cases per season using Faison as the base location

Plant sites	Total combined costs	Average combined costs	Change in costs
	(dol. per season)	(dol. per case)	(percent)
Faison (base) a/	2,096,491	3.84	.00
Goldsboro	+188	b/	+.01
Smithfield	+816	b/	+.04
Benson	+950	b/	+.04
Magnolia	+11,784	+.02	+.54
Wilson	+13,514	+.02	+.62
Kinston	+15,262	+.03	+.74
Greenville	+23,964	+.04	+1.10
Fayetteville	+25,620	+.05	+1.17
Rocky Mount	+29,934	+.05	+1.37
Bethel	+30,478	+.06	+1.40
Raleigh	+30,498	+.06	+1.40
Washington	+39,026	+.07	+1.79
New Bern	+42,868	+.08	+1.97
Williamston	+49,294	+.09	+2.26
Lumberton	+51,112	+.09	+2.35
Halifax	+58,968	+.11	+2.71
Wilmington	+61,832	+.11	+2.84
Chadbourn	+62,606	+.11	+2.87
Windsor	+62,682	+.11	+2.88
Tabor City	+85,372	+.16	+3.92
Elizabeth City	+126,568	+.23	+5.81

a/This site was selected as the base and absolute values are listed. The values for the other sites represent changes from the base values.

b/Less than $.005.

Choice of any one of several alternative sites for a single plant would increase combined costs less than 1 percent. For example, a Goldsboro location increases combined costs by only $188 when volume is 545,672 cases per season. Other sites that would increase combined costs by less than 1 percent are Smithfield, Benson, Magnolia, Wilson and Kinston. The alternative sites of Goldsboro, Smithfield, and Benson increase combined costs less than $.005 per case. Therefore, the added cost of locating a single plant at one of these sites would be very small. Locating a single plant at Elizabeth City to process all North Carolina supplies would be more costly since average costs would be $.23 per case greater than the average cost for a plant at Faison. This represents an increase of more than 5.8 percent.

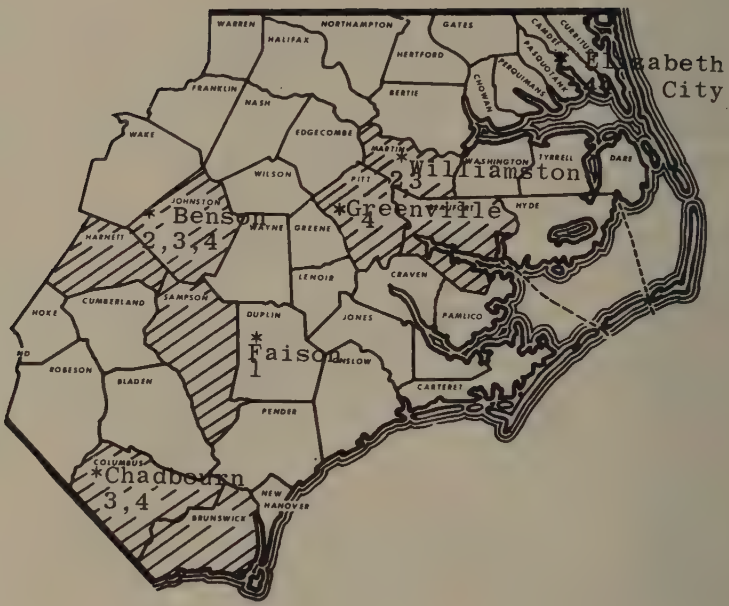


Figure 13. The optimum locations of one, two, three and four plants

With the optimum number of plants established at one and the optimum location designated at Faison, comparison with the location of plants in the 2-, 3- and 4-plant industries may be of interest especially for long-range planning purposes. With the 1960 production pattern, optimum sites for a two-plant industry are Benson and Williamston. Faison is not one of the optimum locations in a two-plant industry. Two of the three large production concentrations would have a plant within their borders. The additional costs of establishing two plants compared to one plant are presented in Table 13. Assuming an area output of 545,672 cases per season, costs would increase $51,108 or $.09 per case. At greater volumes of output, added cost per case decreases. For example, additional cost is $.02 per case at the output of 1,091,343 cases per season.

The three sites which represent minimum combined costs are Benson, Williamston and Chadbourn. Each of the three areas of concentrated production would now contain a processing plant. However, costs encountered in placing a plant in each of the three concentrated areas are increased by $144,993 per season or $.27 per case when 545,672 cases are processed.

For a four-plant industry, the optimum locations are Benson, Chadbourn, Greenville and Elizabeth City. Locating four plants in North Carolina increases costs by $192,584 per season when 545,672 cases are processed. Costs per case increase by $.35 when compared to the optimum one-plant solution. This means that costs of assembly and processing the 545,672 cases have increased to $4.19 per case. When processing 1,091,343 cases per season, average costs in the four plants increase by $.13 per case over the $3.77 per case in the one-plant solution.

Comparison with Present Plant Locations. A comparison of optimum locations in industries with varying numbers of plants with the existing locations of plants provides information concerning the efficiency of the industry. Such comparisons are possible only under the assumption that existing plants have processing cost relationships similar to those assumed in this study.

Short-run cost comparisons are difficult to make because of the capital investments at the existing plant locations. Therefore, a comparison of combined costs for plants at present locations with costs using optimum plant sites and varying numbers of plants is meaningful only when framed in a long-run context.

Three sweet potato processing plants in operation in 1960 were located at Lumberton, Tabor City and Williamston. Costs of operating with plants in these three locations compared to costs at optimum sites are presented in Table 14.

Table 13. Comparison of combined costs of the optimum one-plant solution with more than one plant at four levels of output

Plant number and location a/	Area output b/ (cases per year)			
	272,836	545,672	818,507	1,091,343
	(dollars per season)			
1 best plant: Faison (base) c/	1,089,636	2,096,492	3,103,343	4,110,198
2 best plants: Benson Williamston	+55,944	+51,108	+35,271	+19,434
3 best plants: Benson Williamston Chadbourn	+140,277	+144,993	+89,708	+64,423
4 best plants: Benson Chadbourn Greenville Elizabeth City	+220,463	+192,584	+164,704	+136,824
	(dollars per case)			
1 best plant: Faison (base) c/	3.99	3.84	3.79	3.77
2 best plants: Benson Williamston	+.25	+.09	+.04	+.02
3 best plants: Benson Williamston Chadbourn	+.51	+.27	+.11	+.06
4 best plants: Benson Chadbourn Greenville Elizabeth City	+.81	+.35	+.20	+.13

Table 13 (continued)

---

a/Plant number and location refer to the sites in which a single plant would be located in a 1-, 2-, 3- and 4-plant industry.

b/These volumes represent 10, 20, 30 and 40 percent of total 1960 production.

c/Faison, the optimum location for a 1-plant industry, is used as the base location and absolute values are listed. The values for the other situations represent changes from the base values.

Estimated minimum costs of assembling and processing 545,672 cases in plants located at the existing sites are $2,249,483 per season. This results in an average combined cost of $4.12 per case. The costs of assembling and processing the same output can be reduced $152,992 per season, or $.28 per case, by having a single plant located at Faison. This represents a reduction in costs of 6.8 percent. The two best plants located at Benson and Williamston reduce costs $101,884 per season or $.19 per case. Over 4.5 percent of total combined costs can be saved by processing in the two best plants compared to the three existing plants.

When comparing the three existing plants with the three best plant sites, combined costs are reduced $37,999 per season or $.07 per case. This represents a reduction in costs of 1.7 percent. This reduction in combined costs is due entirely to savings in assembly costs since plants at all sites are considered to have the same processing cost relationship. The three existing plants represent lower combined costs than the four best plants. In fact, combined costs increase $39,592 per season or $.07 per case when the four best plants are considered. This represents an increase in costs of 1.8 percent.

Size of Plants

The size of processing plant at each site refers to the volume processed per season. Once the volume of output is specified, the rate of output and length of season which minimize costs of processing the specified volume can be determined.

The volume of potatoes processed at each site for a particular combination of plants is determined by allocating production from each supply origin to the plant which offers

Table 14. Comparison of combined costs at three existing plant sites with varying plant numbers and optimum locations assuming area output of 545,672 cases per season

Plant number and location	Total combined cost	Average costs	Change in costs
	(dol./season)	(dol./case)	(percent)
3 existing plants: (base) a/ Tabor City Williamston Lumberton	2,249,483	4.12	base
1 best plant: Faison	-152,992	-.28	-6.8
2 best plants: Benson Williamston	-101,884	-.19	-4.5
3 best plants: Benson Williamston Chadbourn	-37,999	-.07	-1.7
4 best plants: Benson Chadbourn Greenville Elizabeth City	+39,592	+.07	+1.8

a/This situation was selected as the base and absolute values are listed. The values for the other situations represent changes from the base values.

lowest assembly cost. Due to the uneven production density pattern, plants in a dense production area will be allocated more of the total volume than plants in a sparse production area. Therefore, plants will not operate with the same rate of output, total output or length of season.

Since a single plant located at Faison represents the optimum number and location, the rate of output and length of season of a single plant are of primary concern. The procedure for determining the optimum rates of output and lengths of season is discussed in Appendix B. However, this procedure is appropriate only for levels of output which require lengths of season less than 1600 hours.

The optimum size of a single plant is presented in Table 15. For the 545,672 cases per season output, the plant at Faison would minimize total season processing cost if it were designed to process 341 cases per hour and operate the maximum of 1600 hours per season. At this rate of output and length of season, costs of processing are $1,988,000 per season or $3.64 per case.

At the 272,836 case-per-season output, rate of output, length of season and total processing costs are smaller than the 545,672 case-per-season output. However, average processing costs increase. The rate of output decreases from 341 to 205 cases per hour while length of season decreases from 1600 to 1331 hours per season. Total processing costs decrease from $1,988,000 to $1,035,000 per season and average processing costs increase from $3.64 to $3.79 per case.

Table 15. Effects of four levels of output on total season processing costs, optimum rate of output and optimum length of season for a one-plant industry

Item	Description	Area output a/ (cases per season)			
		272,836	545,672	818,507	1,091,343
Optimum rate of output	cases/hour	205	341	512	682
Optimum length of season b/	hours/season	1,331	1,600	1,600	1,600
Total processing costs	1,000 dol./ season	1,035	1,988	2,940	3,892
Average processing costs	dollars/case	3.79	3.64	3.59	3.57

a/These volumes represent 10, 20, 30 and 40 percent of 1960 commercial production in the study area.

b/Length of season was not permitted to exceed 1600 hours per season.

Total processing costs have been based on a price of $2.00 per hundredweight for green potatoes delivered at the plant. Since the producers usually pay the costs of assembling sweet potatoes, net farm price is determined by subtracting the assembly costs from the plant price. The net farm price declines as the distance from the plant to production origin increases. The concentric circles around Faison represent varying net farm prices (Figure 14). Net farm price is greater than $.68 per hundredweight over the entire supply area and for a very large part of the area is more than $1.09 per hundredweight. Since assembly costs average $.20 per case or $.518 per cwt., the average farm price is $1.482 with the f.o.b. plant price of $2.00 per cwt.

With the 1960 production density pattern, the relationship between sizes of plant and costs of processing 545,672 cases in the two best plants located at Benson and Williamston is presented in Table 16. The plant at Benson was allocated 376,738 cases or about 69 percent of the total 545,672 cases. The plant at Benson would minimize processing costs by constructing a plant to process 241 cases per hour and operating 1563 hours per season. Processing costs are estimated to be $1,397,823 per season or $3.71 per case.

Table 16. Output, optimum rate of output, optimum length of season and processing costs when 545,672 cases of sweet potatoes are processed at the best two plants

Item	Unit	Plant site	
		Benson	Williamston
Output	cases/season	376,738	168,934
Optimum rate of output	cases/hour	241	161
Optimum length of season	hours/season	1,563	1,049
Processing costs	dol./season	1,397,823	672,462
	dol./case	3.71	3.98

The plant located at Williamston was allocated 168,934 cases or about 31 percent of the total output. This plant would be designed to operate at 161 cases per hour for 1049 hours per season. Processing costs were estimated at $672,462 per season or $3.98 per case. Thus, the plant at Williamston would be operating at a cost of $.29 per case greater than the plant at Benson.

The supply boundary separating the two processing plants is presented in Figure 15. All of the supply origins east of the boundary line would find it advantageous to ship to Williamston. These would include Northampton, Halifax, Edgecombe, Greene, Lenoir and parts of Wilson and Onslow counties. The supply area west of the counties listed above

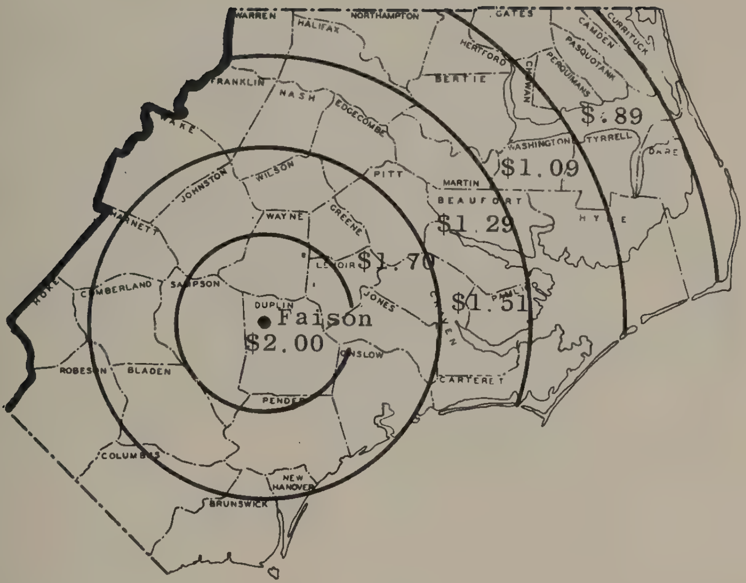


Figure 14. The net farm prices received by producers and the boundary of the supply area for the one best plant located at Faison, North Carolina, 1960

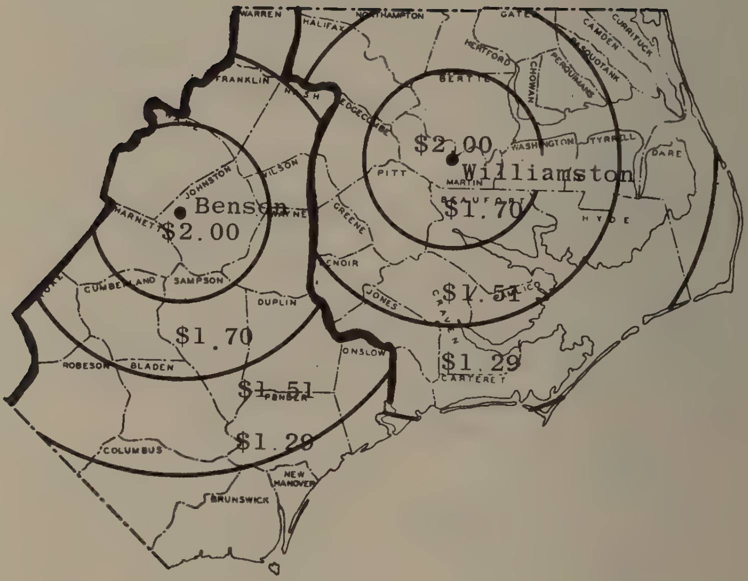


Figure 15. The net farm prices received by producers and the supply area boundaries for the best two plants located at Benson and Williamston, North Carolina, 1960

would minimize assembly costs by shipping to Benson. The boundary line places two of the three concentrated areas of production in the Benson supply area which is the major reason Benson receives the largest portion of the total production.

The minimum net farm price received by producers would be around $1.05 per hundredweight with producers in Brunswick County receiving the lowest net farm price. Most of the producers in three concentrated areas would receive more than $1.09 hundredweight net over assembly costs. With an f.o.b. plant price of $2.00 per cwt. and assembly costs averaging $.368, net farm price would average $1.632 per cwt.

When the three best plants located at Benson, Williamston and Chadbourn are considered, the total volume of 545,672 cases is further divided. Table 17 presents the volumes allocated to each plant as well as rate of output, length of season and costs of processing.

Table 17. Output, optimum rate of output, optimum length of season and processing costs when 545,672 cases of sweet potatoes are processed at the best three plants

Item	Unit	Plant site		
		Benson	Williamston	Chadbourn
Output	cases/season	282,468	168,934	94,270
Optimum rate of output	cases/hour	208	161	120
Optimum length of season	hrs./season	1,358	1,049	786
Processing costs	dol./season	1,068,764	672,462	411,830
	dol./case	3.78	3.98	4.37

Volume going to the plant at Williamston did not change when the third plant was introduced, but the supply area formerly held by Benson was subdivided. The division left the plant at Benson with 282,468 cases per season and allocated the plant at Chadbourn 94,270 cases. The plant at Benson minimizes processing costs by designing a plant to process 208 cases per hour and to operate 1358 hours per season. Total processing costs at Benson decreased from $1,397,823 per season in the two-plant case to $1,068,764 per season in the three plants as one would expect because of the lower volume received (compare Tables 16 and 17).

However, average processing costs at Benson increase from $3.71 to $3.78 per case. The plant at Chadbourn was allocated 94,270 cases per season. With this very low output, optimum rate of output was 120 cases per hour and optimum length of season was 786 hours. Total processing costs in the plant at Chadbourn were $411,830 per season or $4.37 per case.

Supply boundaries of the three plants are illustrated in Figure 16. The plant at Chadbourn was allocated counties south of and including Robeson, Bladen, Pender and parts of Hoke and Duplin counties. The Benson supply area was reduced to counties north of this boundary line. The eastern boundary of Benson was not affected. After the subdivision, Benson was left with only one of the three major concentrations of production. The supply area of the plant at Williamston was not changed. Therefore, the volume of output allocated to Williamston is not affected by introducing the third plant at Chadbourn.

With the three best plants, producers would receive a net farm price of more than $1.29 per hundredweight. Producers in Dare and Currituck counties would receive the lowest net farm prices. Producers in the three concentrated areas would receive a net farm price of more than $1.70 per hundredweight. Average farm price would be $1.723 per cwt.

The volume of output, length of season, rate of output and processing costs encountered in processing 545,672 cases in the four best plants are presented in Table 18. When comparing the three best plants with the four best plants, Williamston is replaced by Greenville and Elizabeth City. The plant at Benson is allocated a smaller proportion of the total volume with four plants compared to the three-plant allocation. Therefore, the rate of output decreases from 208 to 203 cases per hour (compare Tables 17 and 18). The length of season decreases from 1358 to 1318 hours per season. Total processing costs decrease from $1,068,764 to $1,016,436 per season. Average processing costs increase by $.02 from $3.78 to $3.80 per case. The supply area of the plant at Chadbourn is unaffected by introduction of the fourth plant. Thus, the same size of plant in the three-plant solution would be optimum in the four-plant solution. The volume of output formerly going to Williamston in the three-plant solution was allocated to plants in Greenville and Elizabeth City. The plant at Greenville was allocated 126,839 cases per season which required a plant designed to process 140 cases per hour and to operate at 906 hours per season. Processing costs were $525,525 per season or $4.14 per case. The plant at Elizabeth City was allocated 57,807 cases per season. The optimum rate of output was 94 cases per hour and length of season was 607 hours. Processing costs were $282,049 per season or $4.94 per case. In this four-plant analysis the fact that Virginia supplies have not been considered is clearly an important fact to keep in mind.

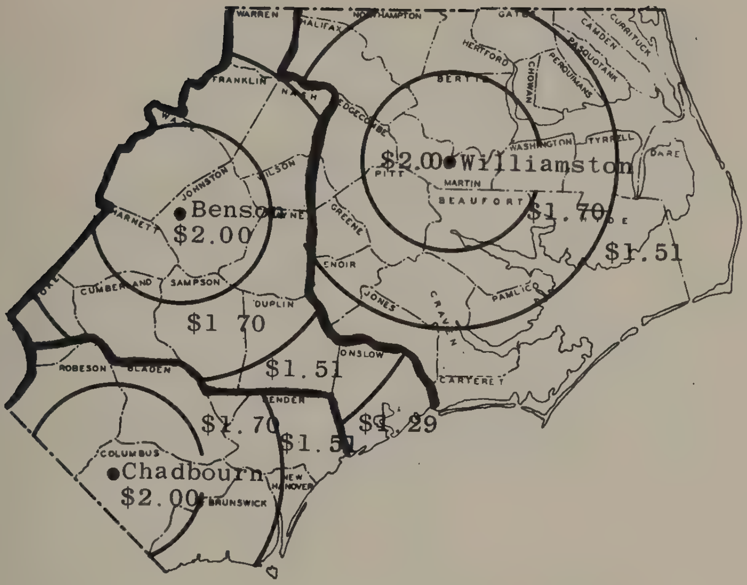


Figure 16. The net farm prices received by producers and the supply area boundaries for the best three plants located at Benson, Chadbourn and Williamston, North Carolina, 1960

Table 18. Output, optimum rate of output, optimum length of season and processing costs when 545,672 cases of sweet potatoes are processed at the best four plants

Item	Unit	Plant site			
		Benson	Chadbourn	Greenville	Elizabeth City
Output	cases/season	267,477	94,270	126,839	57,087
Rate of output	cases/hour	203	120	140	94
Length of season	hrs./season	1,318	786	906	607
Processing costs	dol./season	1,016,436	411,830	525,525	282,049
	dol./case	3.80	4.37	4.14	4.94

The supply boundaries for the best four plants are presented in Figure 17. The supply areas of plants in Chadbourn and Benson were changed very little from the three-plant solution. The plant at Chadbourn had the same supply in both the three- and four-plant solutions. The plant at Benson lost all of Onslow and Wilson counties and part of Wayne County to the plant at Greenville when comparing the three- and four-plant solutions.

The net farm price was greater than $1.51 per hundredweight for most producers; however, producers in Pender and Onslow counties received less than the $1.51 per hundredweight. The producers in the three areas of concentrated production received a net farm price of more than $1.70 per hundredweight.

The volume of output, length of season, rate of output and processing costs encountered in processing 545,672 cases in the three existing plants can be determined if all supply points ship to their best plant. This information is presented in Table 19. The plants at Williamston and Lumberton were allocated the largest part of the 545,672 cases of output. The plant at Williamston was allocated 207,032 cases per season. The optimum rate of output was 178 cases per hour and length of season was 1163 hours. Total processing costs were $805,447 per season or $3.89 per case. The plant at Lumberton received a larger proportion of total output than the plant at Williamston. Therefore, average processing costs were $3.81 per case or $.08 per case less than the $3.89 per case in the Williamston plant. The plant at Tabor City received a very small proportion of the 545,672 cases. Therefore, optimum rate of cutput was only 112 cases per hour

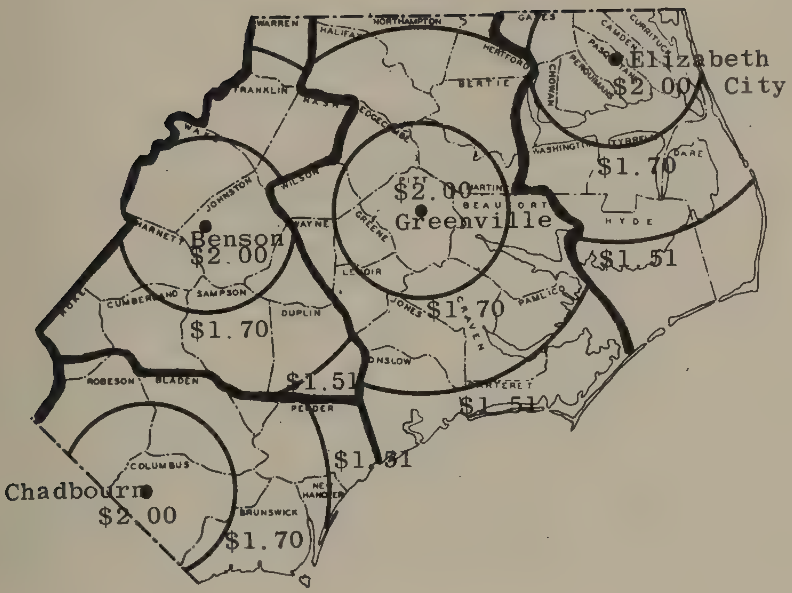


Figure 17. The net farm prices received by producers and the supply area boundaries for the best four plants located at Benson, Chadbourn, Greenville and Elizabeth City, North Carolina, 1960

Table 19. Output, optimum rate of output, optimum length of season and processing costs when 545,672 cases of sweet potatoes are processed at the three existing plants

Item	Unit	Plant site		
		Williamston	Tabor City	Lumberton
Output	cases/season	207,032	81,584	257,056
Optimum rate of output	cases/hour	178	112	199
Optimum length of season	hrs./season	1,163	728	1,292
Processing costs	dol./season	805,447	367,558	980,061
	dol./case	3.89	4.51	3.81

and length of season was 728 hours. Processing cost was a high of $4.51 per case.

Supply boundaries separating the three processing plants are presented in Figure 18. The plant at Tabor City was allocated the production in Brunswick, Pender, New Hanover and parts of Columbus and Duplin counties. The plant at Lumberton was allocated all the counties composing the largest area of concentrated production. The plant at Williamston was allocated all of the production in the eastern counties of North Carolina.

The net farm price for most of the area was greater than $1.09 per hundredweight as illustrated by the concentric circles in Figure 18. However, the heavy concentration of production in Johnston County received less than $1.29 per hundredweight.

Sensitivity to Changes in Assumptions

Many assumptions were necessary in this analysis in order to handle all the variables involved. Among the more important assumptions are those related to processing costs, assembly costs and volume of output. The effects of varying volume of output have been demonstrated. Effects of changes in processing-input prices on the optimum solution can also be demonstrated. The introduction of multiple-product lines would affect the optimum solution in the same general way as reducing processing-input prices. A brief discussion of these possibilities follows.

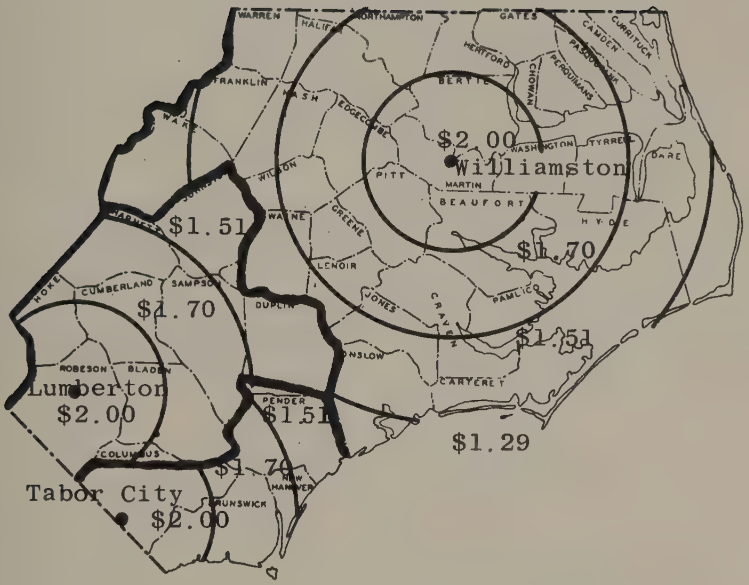


Figure 18. The net farm prices received by producers and the supply area boundaries for the three existing plants located at Tabor City, Lumberton and Williamston, North Carolina, 1960

Effects of Processing-Input Prices. An analysis of the effects of changes in processing-input prices provides a test of stability of the optimum solution. If number, size and location of plants change with relatively small changes in processing-input prices relative to assembly costs, the solution would be considered unstable. On the other hand, the optimum solution could be considered stable if the solution did not change when processing-input prices change over a wide range holding assembly costs constant.

Changes in processing-input prices which affect variable processing costs only would not be expected to change the optimum solutions. For example, green sweet potato prices would not have any effect on the optimum solution if the quantity and density pattern of sweet potatoes did not change. Other processing inputs which would properly fit into this category would be cans, cases, variable labor supply and other inputs which vary directly with output. Changes in processing-input prices which could affect the optimum solution would apply to inputs composing the minimum cost of establishing and maintaining a processing plant. Most durable goods would be classified in this group. However, some nondurable goods are also included in the cost of adding a new plant. The minimum cost of establishing a processing plant is affected directly as the price of these inputs is changed while assembly costs are held constant. The effects are as follows:

Decrease in input prices	Minimum cost of adding a plant (dollars/season)
base prices	82,781
- 10%	74,503
- 20%	66,225
- 30%	57,947

The minimum cost of establishing and maintaining a processing plant decreases from $82,781 to $74,503 if particular processing-input prices decrease by 10 percent. A 30 percent decrease in input prices will reduce the minimum cost of establishing a processing plant to $57,947. To test the sensitivity of the input prices on the optimum number, size and location of processing plants, this minimum cost is compared with the change in assembly costs when additional plants are considered.

Since the optimum solution resulted in a one-plant industry, the possibility of a two-plant industry is of primary interest. The second plant would be considered as an optimum solution if the cost of assembling sweet potatoes were greater than the minimum cost of adding a plant. In an earlier section concerning assembly cost, the largest reduction in assembly cost when the second plant was considered occurred at an output of 1,091,343 cases as presented in Table 20. The reductions in assembly costs at four levels of output were estimated to be the following.

Table 20. Reduction in assembly costs at four levels of area output as additional plants are considered

Change in number of plants	Area output (cases per season)			
	272,836	545,672	818,507	1,091,343
	(dollars per season)			
1 to 2 plants	15,837	31,673	47,510	63,347
2 to 3 plants	9,448	18,896	28,344	37,792
3 to 4 plants	2,595	5,190	7,785	10,380

The maximum reduction in assembly costs occurs when the second plant is added and volume of output is 1,091,343 cases per season. This reduction in assembly costs was $63,347 per season. The increase in processing cost is $57,947 when a second plant is added with a 30 percent reduction in selected processing input prices. In this case, a second plant would be added. However, a second plant would not be included in an optimum solution at lower volumes of output or with smaller reductions in input prices. Therefore, it is concluded that the one-plant solution represents a very stable optimum.

Effects of Multiple-Product Plants on Number, Size and Location of Plants. Another possibility which may change the optimum number, size and location of plants processing sweet potatoes is multiple-product plants. The introduction of multiple-product plants would tend to change the number of plants in the same manner as reducing particular processing-input prices. However, the particular pattern of change is much more difficult to measure. Minimum costs of establishing and maintaining a plant for processing would likely be increased when a multiple-product plant was established due to the cost of additional specialized equipment required to process the multitude of products. However, the proportion of the minimum costs charged to add any one product should be lower than the minimum costs of a new, specialized single-product plant. The amount of reduction would depend on the change in minimum costs of establishing a multiple-product plant compared to establishing a specialized sweet potato plant and the proportion of the minimum costs which could be allocated to each of the multitude of products.

The optimum number of plants processing sweet potatoes in a multiple-product plant industry would tend to be greater than in a specialized sweet potato processing industry.

However, the optimum number of multiple-product plants can be determined only by evaluating the processing costs, assembly costs and production patterns of all products.

Because of the interrelationship among processing and assembly costs and production patterns of all products, optimum sites for specialized processing plants would not necessarily be the same for multiple-product plants as specialized plants even with the same optimum number of plants. The relative production densities and assembly costs of all products would be the determining factor in locating multiple-product plants.

Distribution of Benefits between Producers and Processors

Throughout this analysis, the objective has been to minimize combined assembly and processing costs. The distribution of any savings gained by such a reduction has not been specified. Under the assumption that f.o.b. price for the raw product is equal at all plants, it is clear that processors gain from small plant numbers while producers experience higher net prices with more numerous plants because of lower assembly costs. Comparisons of gains and losses of both groups when f.o.b. price is $2.00 per hundredweight are presented in Table 21. Producers as a group gain considerably less per case than processors lose when more than one plant is operating. When adding a second plant, producers as a group gain about $.06 per case, but processors as a group lose about $.15 per case resulting in a net loss to the industry of $.09 per case. When a fourth plant is considered using the one-plant industry as a base, producers as a group gain about $.10 per case while processors as a group lose about $.45 per case for a net loss to the industry of $.35 per case.

These comparisons between producers and processors are not valid if processors pass on losses from higher processing costs to producers through lower f.o.b. raw product prices or if processors share assembly costs with growers. Changes in combined costs resulting from reduced plant numbers can be interpreted as gains accruing to processors as a group after fully compensating growers for increased assembly costs. For example, if plant numbers were reduced from three to one, processors as a group would gain $.21 per case after paying producers as a group $.09 per case for increased assembly costs. In this situation producers as a group would be indifferent to a reduction in plant numbers since total assembly costs remain unchanged. Stated another way, this would be equivalent to processors paying producers $2.00 per cwt. for the raw product at the farm regardless of farm location.

Table 21. Effects of change in plant numbers on costs using one plant as the base and assuming an area output of 545,672 cases per season

Number of plants	Processing costs a/	Assembly costs b/	Combined costs
		(dollars per season)	
1 (base) c/	1,987,504	108,987	2,096,491
2	+ 82,781	- 31,673	+ 51,108
3	+ 165,562	- 50,569	+ 114,993
4	+ 248,343	- 55,759	+ 192,784
		(dollars per case)	
1 (base) c/	3.642	.200	3.840
2	+ .152	- .058	+ .094
3	+ .304	- .093	+ .211
4	+ .455	- .102	+ .353

a/Table 10.
b/Table 9.
c/This situation was selected as the base, and absolute values are listed. The values for the other situations represent changes from the base values.

CONCLUSIONS

This report outlines certain conditions under which a profitable sweet potato processing industry might develop in 43 eastern North Carolina counties. A well organized sweet potato processing industry is important to both sweet potato producers and processors. An efficient processing industry can benefit producers through lower per unit assembly costs while increased production may benefit processors through lower per unit processing costs.

It was found that one plant was the optimum number for minimizing combined assembly and processing costs at each of four levels of output for the area. The costs of $1,096,491 per season to assemble theraw product and to process area output of 545,672 cases in one plant were considerably lower than costs associated with more than one plant. This represents an average combined cost of $3.84 per case.

At this output, the average cost of assembling the raw product for one plant was $.20 per case and the average cost of processing was $3.64 per case.

Faison was found to be the best location for one plant. Faison is located in Duplin County, which adjoins Sampson, one of the counties included in the heaviest concentration of production. Alternative sites at Smithfield, Benson, Magnolia, Wilson and Kinston for the location of one plant resulted in less than a 1 percent increase in total combined costs. Benson also appears as one of the plant locations in the best two-, three-, and four-plant solutions.

Best plant locations for two specialized processing plants were Benson and Williamston. The minimum area output needed in order for two plants to be optimum was 1,426,130 cases per season. This represents about 52 percent of the commercial production in the supply area in 1960. For 545,672 cases, combined costs were $51,108 per season or $.09 per case more than for the one best plant in Faison. Average assembly costs decreased from $.20 for one plant to about $.14 for two plants, but average processing costs increased from $3.64 to $3.79 per case. Average processing costs increased about $.09 per case more than assembly costs decreased. Optimum rate of output and length of season in each plant were reduced when two plants process the total 545,672 cases per season. The plant at Benson was allocated 69 percent of total quantity or 376,738 cases per season by minimizing assembly costs at each supply point. The plant at Williamston was allocated the remaining 31 percent of the total volume or 168,934 cases.

Optimum locations for the best three plants were Benson, Williamston and Chadbourn. Benson and Williamston represented the optimum locations for plants in both the two- and three-plant solutions. The minimum quantity required to reach a three-plant optimum solution was 2,390,520 cases per season. This volume would represent about 88 percent of the 1960 commercial production in the supply area studied. At the output of 545,672 cases, the increase in total combined costs was $144,993 per season or $.27 per case more than for the best one plant. The plant at Williamston was allocated 31 percent of the 545,672 cases or 168,934 cases. The plant at Chadbourn was allocated only 17 percent of the total volume or 94,270 cases per season.

The optimum locations for the best four plants were Benson, Chadbourn, Elizabeth City and Greenville. Benson and Chadbourn represented the optimum locations for both the three- and four-plant solutions. However, Williamston, which appeared in the three-plant solution, was replaced by Greenville and Elizabeth City. Over 8,703,520 cases were required to reach a four-plant optimum solution. This represented about 319 percent of the 1960 commercial production in the supply area. The plant at Benson was allocated 49 percent of the 545,672 cases or 267,477 cases per season. The plant at Chadbourn was allocated 17 percent of the 545,672 cases or 94,220 cases per season. The plant at Greenville was allocated 126,839 cases per season or 23 percent of the 545,672 cases. The plant at Elizabeth City was allocated 57,087 cases or 10 percent of the total 545,672 cases.

The volume of output, optimum rate of output and length of season were determined for the three existing plants. The largest proportion of the total output was allocated to plants in Williamston and Lumberton. The plant at Tabor City had a relatively small supply area when determined on the basis of minimum assembly costs. The plant at Williamston was allocated 207,032 cases or 38 percent of the 545,672 cases. The optimum rate of output and length of season were 178 cases per hour and 1163 hours per season. The plant at Tabor City was allocated only 81,584 cases or 15 percent of the 545,672 cases. Optimum rate of output and length of season were 112 cases per hour and 728 hours per season. The plant at Lumberton was allocated 257,056 cases or 47 percent of the 545,672 cases. The optimum rate of output and length of season were 199 cases per hour and 1292 hours per season. The average processing costs in the Williamston, Tabor City and Lumberton plants were $3.89, $4.51 and $3.81 per case, respectively.

Conclusions relative to the advisability of encouraging a change in the number and location of existing plants can be reached only after careful consideration is given both to the costs of relocation and the possibility of increasing production within each particular supply area. Information concerning the cost of plant relocation is not available from the data in this study. Continued operation of one or more existing plants might also be somewhat below the level of costs assumed here.

Changes in production density within each plant's supply area required to achieve a specified level of processing costs have been estimated. Data presented by Hammond (1961) suggest a long-run price of $3.86 per case which is the weighted average for the period 1955-1960. This weighted price was based on Maryland-Virginia data and the following distribution of can sizes.

Can size	Distribution (percent)	Average f.o.b. price (dollars per case)
2 1/2	28	4.50
303	18	2.68
3 squat	37	4.10
10	17	4.16

The estimated changes in volume of output which would enable each plant to achieve an average processing cost equal to $3.86 per case are presented in Table 22. Note that this does not include assembly costs. The change in output is computed on the basis of 545,672 cases per season which represents 20 percent of commercial production in the area and is roughly three times the estimated 1960 pack. For the one best plant at Faison, output in the 43-county supply area can decrease by 321,940 cases or 59 percent before processing costs increase to $3.86 per case.

For the best two plants, the volume of output can decrease by 153,006 cases or 41 percent in the Benson supply area, but the volume of output in the Williamston supply area would have to increase by 54,798 cases or 32 percent to yield a processing cost of $3.86 per case. Note that it would be possible for both plants to operate at an average cost lower than $3.86 if the total output were equally divided.

Changes in the volumes of output to achieve an average processing cost of $3.86 per case at each plant in a three-plant solution vary from a negative 21 to a positive 137 percent. The volume required at the Benson plant could decline by 21 percent, but the plant at Chadbourn would require an increase in its supply area of 137 percent. The plant at Williamston would require an increase in production of 32 percent to yield a processing cost of $3.86 per case.

The plant at Benson is allocated a larger volume of output than is required to achieve the $3.86 per case processing costs in the four-plant solution. However, the plants at Chadbourn, Greenville and Elizabeth City would require increased volumes of 137, 76 and 292 percent, respectively.

For the three existing plants to operate at a processing cost of $3.86 per case, volume of output would have to increase in the Tabor City supply area by 174 percent and in the Williamston supply area by 8 percent. Volume of output in the Lumberton supply area could decline by 13 percent.

In general, this analysis shows that plants located outside the Benson supply area will operate at a marked disadvantage with respect to raw product supply when a plant is located at Benson or at an alternative site within the Benson area. This is especially true if volume of output in North Carolina is no more than that estimated by Williams and Allen (1960). In the Williams and Allen study, the estimated 1960 volume of sweet potatoes processed in the three existing plants was only 82,500 hundredweight. This is equivalent to 213,675 cases if trim and peel loss is 40 percent. This volume is considerably less than the lowest level of output (10 percent) used in this study to evaluate locational effects of processing plants. In fact, 213,675 cases represent only 7.8 percent of total 1960 volume produced commercially in the supply area. If the cost

Table 22. Estimated change in area output required to yield a processing cost of $3.86 per case, assuming an initial output of 545,672 cases per season a/

Situation	Initial solution		Change in area output which yields an average processing cost of $3.86	
	Volume	Processing costs		
	(cases/season)	(dollars/case)	(cases/season)	(percent)
A. One best plant:				
Faison	545,672	3.64	- 321,940	- 59
B. Two best plants:				
Benson	376,738	3.71	- 153,006	- 41
Williamston	168,934	3.98	+ 54,798	+ 32
Area total	545,672	3.79	- 98,208	- 18
C. Three best plants:				
Benson	282,468	3.78	- 58,736	- 21
Williamston	168,934	3.98	+ 54,798	+ 32
Chadbourn	94,270	4.37	+ 129,462	+ 137
Area total	545,672	3.95	+ 125,524	+ 23
D. Four best plants:				
Benson	267,477	3.80	- 43,745	- 16
Chadbourn	94,270	4.37	+ 129,462	+ 137
Greenville	126,839	4.14	+ 96,893	+ 76
Elizabeth City	57,087	4.94	+ 166,645	+ 292
Area total	545,672	4.10	+ 349,255	+ 64
E. Three existing plants:				
Tabor City	81,584	4.51	+ 142,148	+ 174
Lumberton	257,056	3.81	- 33,324	- 13
Williamston	207,032	3.89	+ 16,700	+ 8
Area total	545,672	3.95	+ 125,524	+ 23

a/Note that assembly costs are not included here.

estimates used in this study are appropriate, one is lead to the conclusion that processing costs were above $3.86 per case at 1960 processing volumes.

This analysis indicates that gains in processing costs would exceed added assembly costs incurred by reducing the number of plants under present supply conditions. Even though assembly costs increase as the number of plants changes from three to one, total assembly and processing costs are minimized if one processing plant is located at Faison or at alternative sites in Johnston, Wayne or Wilson counties. Efforts by plant operators to increase output through a larger contribution to assembly costs would appear quite profitable. Availability of raw product supplies in Virginia and South Carolina may also offer an opportunity to reduce unit costs in the event that local supplies fall short of those needed for capacity operation.

LIST OF REFERENCES

French, B. C., Samet, L. L. and Bressler, R. G. 1956. Economic efficiency in plant operations with special references to the marketing of California pears. Hilgardia, No. 19, Vol. 24, University of California, Berkeley.

Hammond, L. H. 1961. An evaluation of the opportunity for investment in sweet potato canning plants in North Carolina. Unpublished Ph.D. Thesis, North Carolina State College, Raleigh (University Microfilms, Ann Arbor).

Hammond, L. H. and King, R. A. 1962. Planning data for the sweet potato industry: 2. Costs and returns for a model canning plant. A. E. Information Series No. 93, North Carolina State College, Raleigh.

Mathia, G. A. 1962. Selection of the optimum number, size and location of processing plants: An application to the sweet potato industry of eastern North Carolina. Unpublished Ph.D. Thesis, North Carolina State College, Raleigh (University Microfilms, Ann Arbor).

Mathia, G. A. and King, R. A. 1962. Planning data for the sweet potato industry: 1. Prices, production and assembly costs. A. E. Information Series No. 92, North Carolina State College, Raleigh.

N. C. Department of Agriculture. 1962. North Carolina Agriculture Statistics. Number 107, Federal-State Crop Reporting Service, Raleigh, N. C.

Pasour, E. C., Jr. and Toussaint, W. D. 1960. Economic opportunities for adjustments on tobacco farms in the central coastal plains, North Carolina. A. E. Information Series No. 80, North Carolina State College, Raleigh.

Stollsteimer, J. F. 1961. The effect of technical change and output expansion on the optimum number, size and location of pear marketing facilities in a California pear producing region. Unpublished Ph.D. Thesis, University of California, Berkeley (University Microfilms, Ann Arbor).

Williams, F.W. and Allen, M. B. 1960. The southeastern vegetable processing industry, 1960. U. S. Department of Agriculture Marketing Research Report No. 527, U. S. Government Printing Office, Washington.

APPENDIX A

APPENDIX A

The analytical procedure for determining the number, size and location of processing plants that minimize the combined assembly and processing costs requires statements of the relationships of these two functions to volume of output. The following model adapts the economic logic of location theory to the empirical analysis required in determining the optimum number, size and location of processing plants.

Given I raw material origins each of which produces a specified quantity X_i of the raw material to be assembled and processed at one of L possible processing plant locations in the supply area, what are the number, size and location of plants which will minimize the costs of assembling and processing the total quantity of raw material produced in the supply area?

Let TC = total processing and assembly costs,

TAC = total assembly cost,

TSPC = total season processing costs,

L_j = location of plant j,

P_j = unit processing cost of plant j j $(j = 1 \ldots\ldots J \leq L)$ located at L_j,

X_j = quantity of raw material processed at plant j,

X_i = quantity of raw material produced at origin i per production period,

X = total quantity of raw material produced in supply area,

X_{ij} = quantity of raw material transported from origin i to plant j located at L_j,

C_{ij} = unit cost of transporting the raw product from origin i to plant j located at L_j, and

L_J = one combination of locations for J plants among the $\binom{L}{J}$ possible combinations of locations for J plants, given L potential plant locations.

The assembly cost relationship is stated algebraically as

$$\text{(A.1)} \quad \underset{(J,L_j)}{\text{TAC}} = \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \,|\, L_J$$

The total season processing cost relationship is expressed as

$$(A.2) \qquad \underset{(J,L_J)}{TSPC} = \sum_{j=1}^{J} P_j X_j | L_J$$

These two relationships are stated algebraically as a sum.

The procedure is to minimize the combined function:

$$(A.3) \qquad \underset{(J,L_J)}{TC} = \sum_{j=1}^{J} P_j X_j | L_J + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} | L_J$$

with respect to plant numbers J ($J \leq L$) and locations

L_J ($L_J = 1, \ldots, \binom{L}{J}$) subject to

$$\sum_{j=1}^{J} X_{ij} = X_i$$

$$\sum_{i=1}^{I} X_{ij} = X_j$$

$$\sum_{i=1}^{I} X_i = \sum_{j=1}^{J} X_j = X$$

$$X_{ij} \geq 0 \qquad X_j \geq 0$$

The procedure followed in minimizing Equation A.3 with respect to plant numbers and locations is affected by the presence or absence of economies of scale in processing and the effects of plant location on processing costs. Four possible cases of processing relationships and their effects on the optimum number, size and location of processing plants are discussed by Stollsteimer (1961). For the purpose of this study, it is assumed that (1) economies of scale in processing exist and (2) processing costs are independent of plant location.

The total planning cost function is assumed to be linear and positively sloping with a positive intercept, and plants at each possible location use the same production techniques. These limiting assumptions simplify the analytical procedure. French, et al. (1956) showed that these assumptions are consistent with the cost-output relationship found in many processing operations. It is assumed that this type of relationship is satisfactory for long-run planning purposes.

Under these circumstances, the problem of minimizing Equation (A.3) with respect to plant numbers (J) and locations (L_J) is a three-step process. The first step is to compute a transfer cost function which is minimized with respect to plant locations for varying values of J. For a specified number of plants, J, there are $\binom{L}{J}$ possible combinations of locations.

The transportation cost table or matrix C_{ij} can be partitioned into a submatrix $(C^*_{ij})|L_J$ for each combination of locations, L_J. This submatrix $(C^*_{ij})|L_J$ will be (IXJ) with the elements of the J columns representing the assembly costs from each origin to one of the plant locations being considered. A (Ix1) column vector $(\overline{C_{ij}}|L_J)$ is obtained by selecting the minimum C_{ij} from each row of the submatrix $(C^*_{ij}|L_J)$. Minimum total transfer cost with J plants at a specified combination of locations L_J is the product of the row vector (X_I) whose elements X_i represent the quantities of raw material available at each of the I origins and the column vector $C_{ij}|L_J$. For each value of J there are $\binom{L}{J}$ values of $(X_i)C_{ij}|L_J$. The minimum of these values over L_J is the minimum point on an assembly cost function minimized with respect to plant location. This takes on the functional form of

$$\overline{TAC}|J = \underset{L_J}{\text{min.}} (X_i)\ \overline{C_{ij}}|L_j$$

where $\overline{TAC}$ = total assembly cost minimized with respect to plant locations for each value of J (J = 1 .....L),

(X_i) = a(1 x I) vector whose entries, X_i, represent the raw material produced at each of the I origins and

$(\overline{C_{ij}})|L_J$ = a vector whose entries c_{ij} represent minimum transfer cost between each origin and a specified combination of locations, L_J for J plants.

The second step in determining the optimum number, size and location of processing plants is to derive the relationship between the cost of processing a fixed quantity of raw material and varying numbers of plants. With constant and equal marginal processing costs for all plants and a positive intercept in the plant cost function, the total cost of processing a fixed quantity of raw material, X, will increase by an amount equal to the intercept value of the plant cost function with each additional plant.

The intercept value of the plant cost function does not necessarily represent only the cost of durable goods associated with short-run fixed costs. A better description of this intercept value is that it represents the minimum costs associated with establishing and maintaining a processing plant.

The final step in this three-step process is to derive a total combined cost function by adding the total assembly cost function $\overline{TAC}$ and the total processing cost function TSPC for varying numbers of plants. The number of plants which minimizes this total cost function (TC) depends on the rates of change in $\overline{TAC}$ and TSPC. Since the $\overline{TAC}$ function would be expected to decline and TSPC to increase as the number of plants increases, TC would fall only if the decrease in $\overline{TAC}$ was greater than the increase in TSPC. Figures 3 and 4 present an example of the expected shapes of the three functions and illustrate a two-plant optimum solution. The amount processed in each plant is equal to $\sum_{i=1}^{I} X_{ij} = X_j$ for each value of J.

APPENDIX B

APPENDIX B

The procedure for estimating the optimum rates of output and lengths of season for varying levels of output (V) to minimize processing costs is a constrained-minimization problem. Total processing costs are minimized subject to the constraint that rate of output (R) times length of season (L) equals V.

The procedure to determine the optimum rates of output and lengths of season can be demonstrated for the total season processing cost function, TSPC = $a + b_1R + b_2H + b_3HR$, where a, b_1, b_2 and b_3 are parameters.

First, form the function:

(1) $$Z = a + b_1R + b_2H + b_3HR + \lambda\ (V - RH)$$

where λ is an undetermined Lagrange multiplier.

Second, set the partial derivatives of Z with respect to H , R and λ equal to zero and solve for the three unknowns simultaneously.

(2) $$\frac{\partial Z}{\partial R} = b_1 + b_3H - \lambda H = 0$$

(3) $$\frac{\partial Z}{\partial H} = b_2 + b_3R - \lambda R = 0$$

(4) $$\frac{\partial Z}{\partial \lambda} = V - RH = 0$$

Solve (2) and (3) for λ

(5) $$\lambda = b_3 + \frac{b_1}{H} = b_3 + \frac{b_2}{R}$$

Solve (5) for H

(6) $$H = \frac{b_1R}{b_2}$$

Solve (4) for R

(7) $$R = \frac{V}{H}$$

Solve (6) and (7) for H

$$(8)\ H = \sqrt{\frac{b_1 V}{b_2}}$$

Substitute (8) into (7) for R

$$(9)\ R = \sqrt{\frac{b_2 V}{b_1}}\ .$$

Agricultural Experiment Station

North Carolina State College

Raleigh, N. C.

R. L. Lovvorn, Director of Research

Bulletins of this station will be sent free to all citizens who request them.

E. INFORMATION SERIES NUMBER 108
PARTMENT OF AGRICULTURAL ECONOMICS
NORTH CAROLINA STATE OF THE
VERSITY OF NORTH CAROLINA AT RALEIGH
DECEMBER, 1963

Planning Data For The Sweet Potato Industry

4. Costs and Returns from Curing, Storing, Grading and Packing Sweet Potatoes

33.492
[illegible]P
v.4

Planning Data For The Sweet Potato Industry

4. Costs and Returns from Curing, Storing, Grading and Packing Sweet Potatoes

Gene A Mathia

Richard A. King

A.E. INFORMATION SERIES NUMBER 108
DEPARTMENT OF AGRICULTURAL ECONOMICS
NORTH CAROLINA STATE OF THE UNIVERSITY OF NORTH CAROLINA AT RALEIGH
DECEMBER, 1963

PREFACE

This report is the fourth in a series on Planning Data for the Sweet Potato Industry to be published by the Department of Agricultural Economics, North Carolina State of the University of North Carolina at Raleigh. It provides background data for firms currently engaged in or considering entering the sweet potato processing industry. Other reports in the series are: (1) "Prices, Production and Assembly Costs," by Gene A. Mathia and Richard A. King, A. E. Information Series No. 92, June 1962; (2) "Costs and Returns for a Model Canning Plant," by Leigh H. Hammond and Richard A. King, A. E. Information Series No. 93, June 1962; and (3) "Selection of the Optimum Number, Size and Location of Processing Plants in Eastern North Carolina," by Gene A. Mathia and Richard A. King, A. E. Information Series No. 97, December 1962.

These studies contribute to the regional program of vegetable marketing research being conducted in the South under SM-8, Evaluation of Alternative Vegetable Marketing Organization and Handling Methods. Other agencies cooperating in this research are the agricultural experiment stations in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Puerto Rico, South Carolina, Tennessee, Texas and Virginia and the Marketing Economics Division of the United States Department of Agriculture.

TABLE OF CONTENTS

	Page
SUMMARY	3
INTRODUCTION	5
DURABLE COSTS FOR MODEL HOUSES	8
ANNUAL COST OF DURABLE GOODS	10
VARIABLE OPERATING COSTS	12
TOTAL SEASON COSTS	18
ESTIMATED REVENUES	23
EFFECTS OF LESS THAN CAPACITY OPERATIONS	25
SUMMARY	27
LIST OF REFERENCES	30
APPENDIX	31

SUMMARY

This report provides information concerning the costs and returns from sweet potato curing and storing operations. Effects of price of green potatoes, price of cured potatoes, quantity stored, rate of operation and percent packout on costs and returns were examined.

Costs of curing and storing sweet potatoes in North Carolina were estimated for four model plants with storage capacities of 20, 40, 60, and 80 thousand bushels. Data which were synthesized using the economic-engineering approach were supplemented with accounting data obtained for existing operations in North Carolina collected in the spring of 1962. Four levels, 80, 85, 90, and 95 percent of packout, were considered. Although 100 percent of rated capacity was used as a base, effects of less-than-capacity operation on costs were evaluated by considering 50 and 75 percent of rated capacity.

Revenues were estimated for varying levels of output and prices of cured potatoes. Net returns were computed for alternative packout levels, prices of green and cured potatoes and operating capacities.

The estimated cost of curing and storing sweet potatoes, excluding raw product cost, in a house with 20,000 bushels stored per year was between 26 and 29 cents per bushel stored depending on the packout level. This does not include the direct costs of shrinkage. For a house curing and storing 40,000 bushels per year, costs were estimated to be between 21 and 24 cents per bushel stored depending on packout level. For larger houses, average costs decrease about one cent for each 20,000 bushels stored.

If one includes the price of green potatoes, costs are naturally increased considerably. For example, a house with 20,000 bushels stored would have costs ranging from $2.26 per bushel stored for 80 percent packout to $2.29 per bushel stored for 95 percent packout, if the price of the green potato is $2 per bushel in both cases. With 80,000 bushels stored costs were estimated at $2.18 per bushel stored for 80 percent packout and $2.21 per bushel stored for 95 percent packout, assuming a $2 green potato price.

In terms of bushels marketed, average costs decrease from $2.83 per marketed bushel for 80 percent packout to $2.41 per marketed bushel for 95 percent packout, when 20,000 bushels are stored and $2 per bushel paid for green potatoes. To cover the cost of curing, storing and shrinkage with 80 percent packout, the price of the cured potatoes marketed by a firm storing 20,000 bushels would have to equal $2.83 or $.83 greater than the price of green potatoes. A firm storing 80,000 bushels could cover average costs at a cured potato price of $2.73 per bushel marketed. A firm storing 80,000 bushels thus has a 10 cent cost advantage over a firm storing 20,000 bushels while a firm with a 40,000 bushel capacity has a 7 cent cost advantage if full capacity operations for both are assumed.

Several factors are important in determining the optimum size of house which a firm should build. The quantity of green potatoes in a supply area and the competition among buyers for this quantity are important in determining the optimum size of house in a particular location. These two factors were not considered in this study, but other studies in this series explore these topics.

Planning Data For The Sweet Potato Industry

4. Costs and Returns from Curing, Storing, Grading and Packing Sweet Potatoes

Gene A. Mathia and Richard A. King

INTRODUCTION

North Carolina is the second largest sweet potato producing state in the nation. Past production has been greater than 1960 production of 2,400,000 hundredweight which is one indication that the state has the potential for expansion under favorable conditions. One important condition is a satisfactory marketing system to handle the increase efficiently.

Around 60 percent of North Carolina's production is marketed in one of three forms: (1) green or uncured, (2) cured, and (3) processed. The volume processed in three existing processing plants in North Carolina in 1960 was estimated by Williams and Allen (1960) to be 82,500 hundredweight or 3.4 percent of 1960 total production. Thus, a very large proportion of total production is marketed on the green or cured markets.

Results of a study by Mathia and King (1962a) indicate that a combination of fresh and processing market sales yielded greater returns to land, management and operator's labor than straight sales to either the fresh or processing market alone. In that study, it was assumed that 20 percent of total sales was canner grade sold to the processing market while 65 percent was number one and 15 percent was jumbo, the latter two being sold on the green or cured markets.

Consumption of green sweet potatoes appears to be limited by the perishable qualities of green potatoes and locational disadvantage of North Carolina growers as compared with other southern states which harvest earlier in the season. However, a limited quantity of North Carolina sweet potatoes is sold green.

Results of a study by Mathia (1962) indicate that the processing industry currently provides adequate facilities to process canner grade sweet potatoes. In fact, excess capacity in processing plants now exists. The processing industry has supplemented the fresh market by processing off-size sweet potatoes. Therefore, the possibility of increasing production and farm income from sweet potatoes through improved fresh marketing and of curing and storing operations is of general interest.

Objectives. Before investment is made in new curing and storing houses, information is needed concerning the conditions necessary for profitable operations. Specific objectives of this study are (1) to estimate costs of curing and storing sweet potatoes, (2) to estimate returns to different size operations, and (3) to indicate the possible effects on returns of changes in size of operation, prices of green and cured potatoes and level of packout of marketable potatoes.

Method of Analysis. Costs of curing and storing sweet potatoes are estimated for four model houses designed for 20, 40, 60 and 80 thousand bushels of green sweet potatoes stored per year. The data concerning curing and storing costs were developed and synthesized by an economic-engineering approach. Building and equipment engineers and equipment company representatives provided specifications for building sizes and designs and estimated costs of buildings and equipment for each size of house.

Visits in the spring of 1962 to eleven existing operations in North Carolina supplemented the data provided by engineers and equipment companies. Labor requirements were estimated through combined effort of existing curing and storing operators and equipment manufacturers.

Revenues were estimated at varying prices of cured potatoes ranging from $2 to $4 per bushel by $.50 intervals. Green potato prices were varied from $1.60 to $2.40 per bushel by $.20 intervals. However, "effective" green potato price depends on the percent packout of marketable potatoes. Packout levels considered include 80, 85, 90, and 95 percent marketable potatoes.

Description of Operations in Model Houses. An outline of major operations in preparing potatoes for the final market is essential to a clear understanding of the storage operation and specification of input-output coefficients to be used in the estimation of costs for each size of operation. A description of the major operations encountered in curing and storing sweet potatoes for fresh market sales is presented in terms of techniques embodied in the four model plants specified for this analysis. Selection of techniques was made on the basis of what would be included in storage houses planned for construction in the future. However, most of these techniques were observed at some stages in one or more existing storage houses. Figure 1 presents a

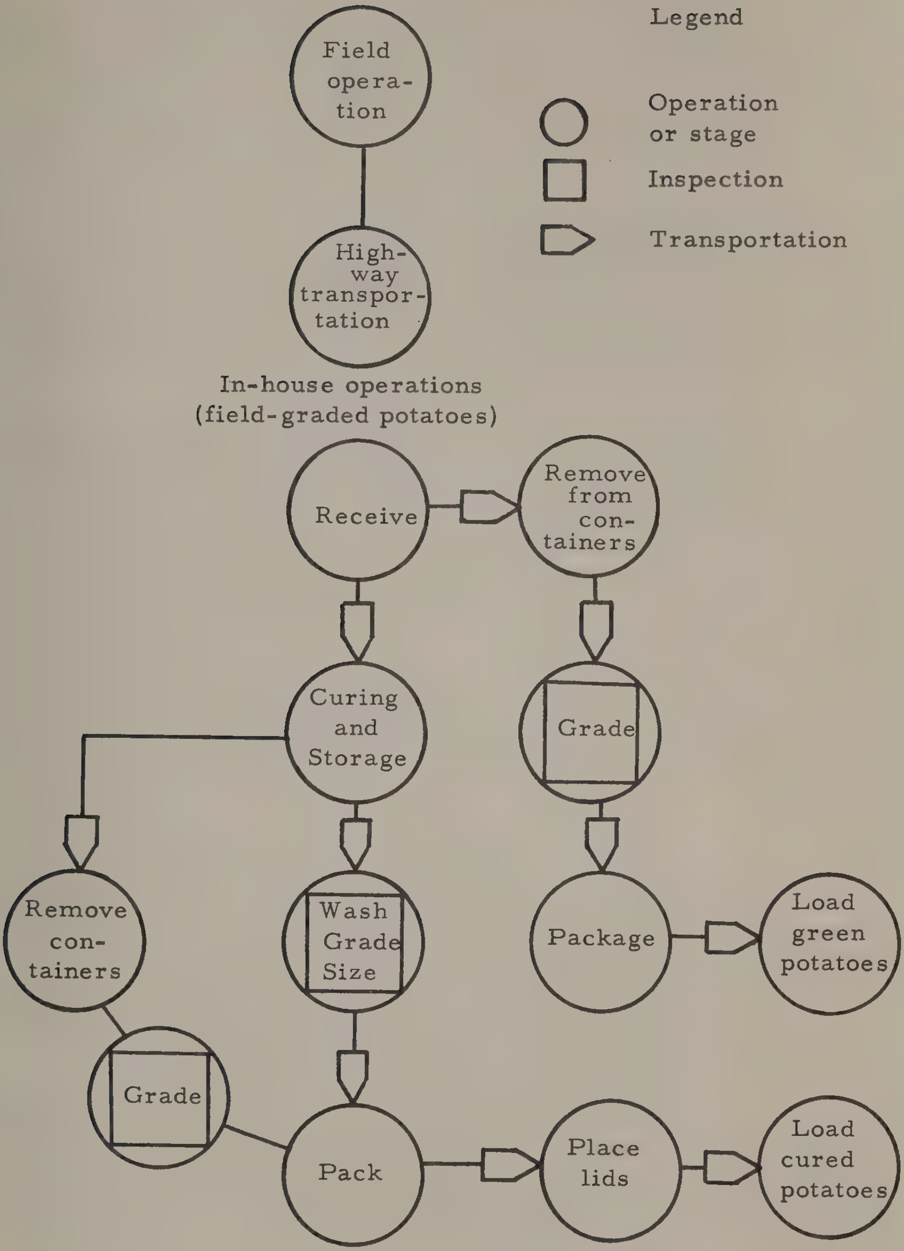


Figure 1. Process flow diagram--Sweet potato assembly and curing and storing operations

flow sequence of operations and gives an indication of direction of flows, time lags and type of equipment used in each operation.

Field-graded sweet potatoes are usually delivered to storage houses in new 50-pound baskets, although some secondhand containers are also used. Cost of the baskets is included in the price paid for raw potatoes. Potatoes to be sold green may be repacked or shipped directly.

Potatoes not sold immediately are stored in the house with aid of conveyors. Potatoes are stacked 8 to 10 baskets high. When a section of the house has been filled, the potatoes are cured at a temperature of 80°-85°F for several days. The primary purpose of curing is to heal cuts, bruises and broken ends with as little shrinkage as possible. After curing is completed, the temperature is reduced and the sweet potatoes are held in storage until needed.

At the time of sale, potatoes are removed from the storage area on conveyors and placed in the dumping area. Here, basket lids are removed and the potatoes are dumped on the elevator leading to the washer. Potatoes move through the washer where dirt and other foreign material are removed. They then move on to the grading belt where they are sorted according to size and quality. Graders sort the different grades of potatoes on the belt and return them to 50-pound baskets or fiberboard boxes.

As the potatoes are packed, liners are inserted and lids placed on the baskets. The quality of product is identified on each basket before being moved to the loading area. At this point, the potatoes are ready for loading and delivery.

DURABLE COSTS FOR MODEL HOUSES

The costs associated with curing and storing operations include both durable and nondurable items. Durables include items purchased in one time period but used over several time periods. These items consist mainly of buildings and equipment. Cost of the building site was not considered in this study because it is relatively small and is influenced more by location of the house than by storage capacity.

Space requirements and labor costs are important determinants of building specifications. Space requirements include the curing and storing area, washing and grading area, office space and service area. Building specifications presented in Table 1 were provided by an engineering consultant. Floor space varied from 5,600 square feet in the 20,000 bushel house to 17,000 square feet in the 80,000 bushel house.

Equipment requirements for the four model houses include conveyors, heaters and a combination washer-grader. Size of the various units depends on size of house and length of time available between curing and final sale. Size of necessary equipment for each size of house as presented in Table 1 was provided by equipment companies who manufacture the various items.

Table 1. Building and equipment specifications for four model sweet potato curing and storing houses

Item	Unit	Capacity of house in thousands of bushels			
		20	40	60	80
Building:					
Overall dimensions	ft.	70x80x10	75x125x10	80x165x10	85x200x10
Volume	cu. ft.	56,000	93,750	132,000	170,000
Floor space:					
Storing & curing	sq. ft.	3,500	6,975	10,500	14,000
Grading & office	sq. ft.	2,100	2,400	2,700	3,000
Total		5,600	9,375	13,200	17,000
Equipment:					
Washer-grader	no.	1	1	1	1
Power rating	h.p.	2	2 1/2	2 1/2	3
Belt width	in.	24	36	36	45
Rated capacity[a]	bu./hr.	200-250	275-350	275-350	400-500
Heating equipment	no.	1	2	2	3
Capacity[b]	BTU	243,850	376,040	506,390	632,940
Power rating	h.p.	2	3	4 1/2	6
Conveyors	lin. ft.	60	80	125	165
Power rating	h.p.	2 1/2	3	3 1/2	4 1/2

[a] Rated capacity depends on quality of sweet potatoes graded.

[b] British thermal units are calculated as follows:

1. Floor heat loss equals 55 (building perimeter in linear feet)
2. Wall heat loss equals 26 (wall area in square feet)
3. Ceiling heat loss equals 15 (ceiling area in square feet)
4. Windows and doors equals (volume of building in cubic feet) $\frac{70}{60}$

Costs for building four model houses were estimated on the basis of concrete block construction, including a four-inch concrete floor and wood frame partitions. Plumbing and electrical wiring are also included in the total cost of facilities presented in Table 2. This type of construction is common in North Carolina and is recommended in building plans provided by engineering research workers.

The initial investment cost for each of four model plants is summarized in Table 2. Total investment in buildings and equipment varied from $15, 185 for the 20, 000 bushel house to $40, 010 for the 80, 000 bushel house. Investment in buildings made up to 60 to 75 percent of the total investment.

Table 2. Building and equipment costs for four model sweet potato curing and storing houses

Item	Capacity of house in thousand bushels			
	20	40	60	80
	(dollars)			
Building				
Storing & curing[a]	6, 125	12,206	18, 375	24, 500
Grading & office[b]	3, 360	3, 840	4, 320	4, 800
Total	9, 485	16, 046	22, 695	29, 300
Equipment[c]				
Washer-grader	4, 230	4, 995	4, 995	5, 730
Heating equipment	670	1, 040	1, 360	1, 730
Conveyors	800	1, 250	2, 085	3, 250
Total	5, 700	7, 285	8, 440	10, 710
Total cost	15, 185	23, 331	31, 135	40, 010

[a] Based on an estimate of $1. 74 per square foot for concrete block, four-inch concrete floor and wood frame partitions.

[b] Based on an estimate of $1. 60 per square foot for concrete blocks.

[c] Includes a 15 percent charge for transportation and installation.

ANNUAL COST OF DURABLE GOODS

The annual cost of durable goods depends on the frequency with which these facilities will become obsolete and be replaced. Annual cost items associated with durable goods include depreciation, interest, insurance, taxes and maintenance. Costs of these items are presented in Table 3. Total annual costs ranged from $1, 874 per season for the 20, 000 bushel house to $4, 648 per season for the 80, 000 bushel house.

The following procedure was used in estimating annual cost of durable goods:

1. Building depreciation was calculated on the basis of a 30-year life.
2. Equipment depreciation was calculated on the basis of a 10-year life.

Table 3. Annual cost of durable goods for four model sweet potato curing and storage houses

Items	Storage capacity in thousand bushels			
	20	40	60	80
	(dollars per year)			
Depreciation:				
Building	316	535	756	977
Equipment	570	728	844	1,071
Interest	456	700	934	1,200
Insurance	152	233	311	400
Taxes	152	233	311	400
Maintenance	228	350	467	600
Total	1,874	2,779	3,623	4,648

3. Interest was calculated at 3 percent of initial investment of building and equipment.
4. Insurance and taxes were calculated at 1 percent of initial investment of building and equipment.
5. Maintenance charges were computed at 1.5 percent of initial cost of building and equipment.

Depreciation. Annual cost of buildings was based on a 30-year life. This planning horizon was consistent with the planning horizon encountered in existing operations. A 10-year planning horizon was used to calculate depreciation on equipment. This planning horizon, too, was consistent with plans of existing operators. Depreciation on buildings ranged from $316 per year on the 20,000 bushel house to $977 per year with the 80,000 bushel house. Depreciation on equipment ranged from $570 per year to $1,071 per year.

Interest. Annual cost of capital for durable investment was assumed to be 6 percent per annum or approximately 3 percent of initial investment in buildings and equipment. This interest charge does not include payment for short-term credit for operating capital. Interest charges were an important cost ranging from $456 per year with a 20,000 bushel house to $1,200 per season with an 80,000 bushel house.

Insurance. The cost of insurance in North Carolina depends on location of building and availability of fire protection. The rate used for this study was $1 per $100 of beginning valuation or 1.0 percent of initial investment cost of buildings and equipment. Insurance charges for sweet potatoes in storage are not included in insurance charges for buildings and equipment. Cost of insurance varied from $152 per year with the 20,000 bushel house to $400 per year with the 80,000 bushel house.

Taxes. Property tax rates on buildings and equipment vary from one location to another. A rate of 1.0 percent of initial cost of buildings and equipment was assumed. Annual cost therefore was the same as the cost of insurance.

Maintenance. Cost of maintaining building and equipment in operating condition is related to both time and use. Annual maintenance cost was estimated at 1.5 percent of initial cost of building and equipment. Thus, cost of maintenance varied from $228 per year with a 20,000 bushel house to $600 per year with an 80,000 bushel house.

VARIABLE OPERATING COSTS

Nondurables are those items which are both purchased and used in the same time period. Nondurable expenses include labor, fuel, insurance on the raw product, water, electricity, telephone and interest on short-term operating capital.

Since capacity of a house is specified in terms of the quantity of green sweet potatoes cured and stored per season, variable input coefficients to show inputs per season are needed for estimating costs. Length of a season is usually 6 months or less so that most variable operating expenses occur within 6 months after sweet potatoes are put in storage. Input requirements for most of the variable inputs are related to quantity of raw products cured and stored although some are related to the quantity of sweet potatoes suitable for marketing. Therefore, an assumption about yield of marketable potatoes is necessary to estimate costs.

Factors which affect yield of marketable sweet potatoes are foreign matter, shrinkage and inferior quality potatoes including strings and decayed potatoes. Even though sweet potatoes are field graded and only the higher quality potatoes are sold to curing and storing firms, the percentage of marketable potatoes varies from 80 to 95 percent. For this reason it is necessary to consider various packout levels of marketable potatoes. The term "marketable" sweet potatoes is used here to refer to all potatoes sold, including U.S. No. 1's, jumbos and low quality roots. Existing storage firms indicated that losses from shrinkage and decay average around 12 percent of the total quantity stored or 88 percent packout.

Raw Product. The size of house determines maximum input of green sweet potatoes. If the four model plants are filled to capacity, the quantity required in each would be 20, 40, 60 and 80 thousand bushels per season. The cost of green sweet potatoes which are marketable after curing and grading is a function not only of the price paid to producers but also of the percent of packout. Adjusted costs of sweet potatoes at varying prices paid to producers and qualities of potatoes are presented in Table 4. At a price of $2 per bushel paid to producers for green sweet potatoes, the cost of the product varies from $2.50 at 80 percent packout to $2.11 per bushel at 95 percent packout.

Table 4. Relationship between price paid for green sweet potatoes, percent of potatoes which are marketable and adjusted cost of potatoes marketed

Price paid for green sweet potatoes	Adjusted cost of green potatoes at various packout rates			
	80%	85%	90%	95%
(dol./bu.)	(dollars/bushel marketed)			
1.60	2.00	1.88	1.78	1.68
1.80	2.25	2.12	2.00	1.89
2.00	2.50	2.35	2.22	2.11
2.20	2.75	2.59	2.44	2.32
2.40	3.00	2.82	2.67	2.53

Labor Requirements. Labor cost varies with size of house, type of equipment and length of time available between curing and marketing the graded product. A work sampling study of eleven storage houses provided estimates of unit time requirements for each job. Manufacturer's rated capacities of machinery also were considered in deriving work standards for each job.

Unit time requirements from the work sampling study were converted to work standards to estimate crew requirements for various house sizes. The work standards in Table 5 do not allow for nonproductive time or unavoidable delay. However, an allowance of 15 percent for nonproductive time is made when labor costs are computed for each model house. Crew requirements and direct labor costs for each size of house are presented in Table 6. The wage rates for each particular job reflect 1962 wage rates in the North Carolina operations surveyed.

Table 5. Job description and work standards for direct labor in sweet potato curing, storing, grading and packing[a]

Job description	Work standard[b]
	(bushels/hour)
Moving into storage:	
Load conveyor to storage	500
Unload conveyor stack	167
Move out of storage:	
Load conveyor from stack	100
Unload conveyor	300
Grading and packing:	
Remove lids and dump	300
Pick out culls and rots	300
Pack marketable potatoes	38
Handle Number 1's	50
Handle Number 2's	300
Handle jumbos	300

[a] Labor requirements are based on recommendations by equipment manufacturing companies and adjusted to fit North Carolina conditions in 1962, using data collected from existing firms.

[b] Refers to bushels of raw product per hour handled by a person of average ability.

Table 6. Crew requirements and direct labor cost per hour of operation for varying sizes of house[a]

Job	Wage rate	Storage capacity in thousand bushels							
		20	40	60	80	20	40	60	80
	(dol. /hr.)	Size of crew (no. of men)				Labor cost (dol. /hr.)			
Move into storage:									
Load conveyor	1.15	1	1	1	1	1.15	1.15	1.15	1.15
Unload conveyor	1.15	1	1	1	1	1.15	1.15	1.15	1.15
Stack	1.15	1	1	2	2	1.15	1.15	2.30	2.30
Move out of storage:									
Remove from stack	1.05	1	1	2	2	1.05	1.05	2.10	2.10
Place on conveyor	1.05	1	1	1	1	1.05	1.05	1.05	1.05
Remove from conveyor	1.05	1	1	1	1	1.05	1.05	1.05	1.05
Remove lids and dump	1.05	1	1	2	2	1.05	1.05	2.10	2.10
Grade and pack:									
Pick out culls and rots	1.05	1	1	2	2	1.05	1.05	2.10	2.10
Pack marketable potatoes	1.05	6	7	8	9	6.30	7.35	8.40	9.45
Handle No. 1's	1.05	3	4	5	6	3.15	4.20	5.25	6.30
Handle No. 2's	1.05	1	1	1	1	1.05	1.05	1.05	1.05
Handle jumbo's	1.05	1	1	1	1	1.05	1.05	1.05	1.05
Supervisor	1.50	1	1	1	1	1.50	1.50	1.50	1.50
Total	--	20	22	28	30	21.75	23.85	30.25	32.35

[a] Assumes a rate of moving potatoes of 200 bushels per hour in 20,000 bushel house, 275 bushels per hour in the 40,000 bushel house, 350 bushels per hour in the 60,000 bushel house and 425 bushels per hour in the 80,000 bushel house. Equipment in four model plants is adequate to grade at least 75 percent of the sweet potatoes stored within 30 days after curing. Distribution of workers on grading and packing line would depend upon quality of potatoes.

Fuel Costs. Heating fuel is required during the curing process on those days during the storing season when temperature in the house falls below 55°F. It is also necessary to heat the area where grading and packing equipment is located as well as the office area. Fuel consumption was computed using data provided by Lutz and Simons (1958). One gallon of fuel per hour was used by the heating system for every 98,000 British thermal units. Cost of fuel varied from \$381 per season with the 20,000 bushel house to \$992 per season with the 80,000 bushel house (Table 7).

Table 7. Estimated total costs associated with operating four model sweet potato curing, storing, grading and packing operations at 100 percent capacity and selected packout levels

Item	Unit	Price	Input quantity				Cost			
			Capacity of house in thousands of bushels				Capacity of house in thousands of bushels			
			20	40	60	80	20	40	60	80
			(units/season)				(dol./season)			
Variable cost										
Labor[a]	man-hrs.	b	2,300	3,681	5,519	6,493	2,501	3,988	5,962	7,001
Fuel[c]	gallons	.160	2,381	3,686	4,963	6,200	381	590	794	992
Insurance on potatoes[d]	bushels[e]	.014	20,000	40,000	60,000	80,000	280	560	840	1,120
Electricity[f]	kwh	.014	6,105	9,650	13,000	17,480	85	135	187	245
Water[g]	1,000 gal.	.150	1,100	2,140	3,180	4,220	165	321	477	633
Interest on potatoes[h]	bushels	.015	20,000	40,000	60,000	80,000	300	600	900	1,200
Sales expense[d]	bushels	.015	20,000	40,000	60,000	80,000	300	600	900	1,200
Miscellaneous expenses[d]	bushels	.007	20,000	40,000	60,000	80,000	140	280	420	560
Total variable cost excluding raw product							4,152	7,074	10,480	12,951
Annual cost of durable goods							1,874	2,779	3,623	4,648
Total variable cost plus cost of durables							6,026	9,853	14,103	17,599
Raw product cost	bushels	2.00	20,000	40,000	60,000	80,000	40,000	80,000	120,000	160,000
Total costs including raw product							46,026	89,853	134,103	177,599
Basket credit										
80 percent packout	baskets	.20	4,000	8,000	12,000	16,000	800	1,600	2,400	3,200
85 percent packout	baskets	.20	3,000	6,000	9,000	12,000	600	1,200	1,800	2,400
90 percent packout	baskets	.20	2,000	4,000	6,000	8,000	400	800	1,200	1,600
95 percent packout	baskets	.20	1,000	2,000	3,000	4,000	200	400	600	800
Total cost adjusted for basket credit										
80 percent packout	--	--	--	--	--	--	45,226	88,253	131,703	174,399
85 percent packout	--	--	--	--	--	--	45,426	88,653	132,303	175,199
90 percent packout	--	--	--	--	--	--	45,626	89,053	132,903	175,999
95 percent packout	--	--	--	--	--	--	45,826	89,453	133,503	176,799

---

[a] Assumes 15 percent as nonproductive time.

[b] Wage rates by job shown in Table 6.

[c] Computed on the basis of one gallon of fuel per hour for every 98,000 British thermal units of the heating system. Assumes 120 heating days per season with an average of 8 hours of heat required per day.

[d] Based on survey data of existing firms.

[e] Baskets containing 50 pounds.

[f] Includes a 20 percent allowance for lighting.

[g] Includes a 40 percent allowance for cleaning and waste.

[h] Computed on the basis of one-half the raw potato price of $2.00 per bushel for a three-month period. No allowance is made for operating expenses.

Insurance on Potatoes. This operating cost is highly variable among the houses studied. Insurance rates not only vary among locations but insurance coverage varies as well. The amount of insurance coverage ranged from zero to near full value of the sweet potatoes in the houses surveyed. Insurance costs were estimated at .014 cents per bushel of sweet potatoes stored covering a time period of about three months. This amounts to $280 per season in a house storing 20,000 bushels and $1,120 per season in a house storing 80,000 bushels (Table 7).

Electricity. Electric power consumption is related to total horsepower necessary to operate a washer-grader, heating system and conveyors. A one horsepower motor consumes approximately one kilowatt of electricity per hour of operation. The total cost of electric power per hour of operation was derived by aggregating motor horsepower plus a 20 percent allowance for lighting. Costs of electricity were estimated at $85 per season in a house storing 20,000 bushels and $245 per season in a house storing 80,000 bushels (Table 7).

Water. Major use of water is in the washing operation. An estimate of water requirements for washing sweet potatoes was provided by the manufacturer of a washer-grader. An allowance of 40 percent was made for cleaning purposes and to allow for waste. Water costs were estimated at $165 per season in a house storing 20,000 bushels and $633 per season in a house storing 80,000 bushels (Table 7).

Sales Expenses. Items included in this category are advertising, telephone, and brand labels. Experience of existing firms indicated that these costs average about 1 1/2 cents per bushel stored.

Interest on Operating Capital. Availability of short-term credit for purchasing green sweet potatoes is a very important consideration in curing and storing operations. Since curing and storing operations occur over a 2- to 6- month period, credit needs were computed on the basis of a 3-month period. Relationship of short-term interest costs and price of the raw product is presented in Table 8. Interest costs for the model houses are summarized in Table 8 for green sweet potato prices ranging from $1.60 to $2.40 per bushel.

Miscellaneous Items. These items of cost include cleaning and fumigating material, basket liners, office supplies and other expenses required to coordinate grading activities . These expenses were estimated from accounting data provided by existing houses at $0.07 per bushel stored (Table 7).

Shrinkage and Loss. Difference between quantity of raw material cured and stored and quantity of finished product packed and sold represents an important cost to marketing firms. Losses due to shrinkage and decay depend to some extent on the quality of green sweet potatoes purchased and stored. However, loss of water during the curing

Table 8. Effect of price of green sweet potatoes and size of house on interest costs, assuming capacity operations[a]

Price of green sweet potatoes	Capacity of house in thousands of bushels			
	20	40	60	80
(dol. /bu.)	(dol. /season)			
1.60	240	480	720	960
1.80	270	540	810	1,080
2.00	300	600	900	1,200
2.20	330	660	990	1,320
2.40	360	720	1,080	1,440

[a] Based on an interest charge of $.015 per dollar of credit. Amount of credit was estimated at one-half the green sweet potato price for an average three-month period.

process accounts for a large part of the total reduction in marketable weight.

Shrinkage losses affect costs both positively and negatively. Of course, the cost effect of loss of weight far outweighs the credit for excess used baskets. Both must be considered in estimating total annual costs of curing and storing sweet potatoes. Costs adjusted for basket credit are presented in Table 7.

TOTAL SEASON COSTS

Model Plant Costs. Total costs of curing, storing, grading and packing sweet potatoes are summarized in Table 9. Adjusted total costs include variable costs plus the cost of durable goods less basket credit, which is a function of packout, but excluding the cost of sweet potatoes. It has been assumed throughout this study that potatoes are delivered in new baskets. Basket credit amounts to roughly one-half the cost of new baskets for that portion of the volume placed in storage which is not marketable.

Average costs excluding raw product range from 22 cents per bushel marketed by the 80,000 bushel house to 31 cents per bushel for the 20,000 bushel house, both computed for 90 percent packout and full capacity operation. Size of house has an important bearing on these cost items but percent packout has very little effect. As has been emphasized above, percent of product packed out has an important influence on the level of costs of raw product. Packed out costs for the 20,000 bushel house range from $2.827 per bushel at 80 percent packout to $2.412 per bushel at 95 percent packout, but the 80,000 bushel house has a cost advantage of 10 cents or less. Size of house thus appears relatively less important than does raw product procurement.

Table 9. Total season costs and cost per bushel packed for four model houses operating at capacity and paying $2 per bushel for green sweet potatoes

Item	Capacity of house in thousands of bushels			
	20	40	60	80
	(dollars/season)			
Total costs[a]				
Variable costs excluding raw product	4,152	7,074	10,480	12,951
Annual cost of durable goods	1,874	2,779	3,623	4,648
Total	6,026	9,853	14,103	17,599
Basket credit				
80 percent packout	800	1,600	2,400	3,200
85 percent packout	600	1,200	1,800	2,400
90 percent packout	400	800	1,200	1,600
95 percent packout	200	400	600	800
Adjusted total costs excluding raw product				
80 percent packout	5,226	8,253	11,703	14,399
85 percent packout	5,426	8,653	12,303	15,100
90 percent packout	5,626	9,053	12,903	15,999
95 percent packout	5,826	9,453	13,503	17,799
Average costs				
Adjusted total costs excluding raw product				
80 percent packout	.327	.258	.244	.225
85 percent packout	.319	.254	.241	.224
90 percent packout	.313	.251	.239	.222
95 percent packout	.307	.249	.237	.221
Raw product equivalent[b]				
80 percent packout	2.500	2.500	2.500	2.500
85 percent packout	2.353	2.353	2.353	2.353
90 percent packout	2.222	2.222	2.222	2.222
95 percent packout	2.105	2.105	2.105	2.105
Total packed out cost				
80 percent packout	2.827	2.758	2.744	2.725
85 percent packout	2.672	2.607	2.594	2.577
90 percent packout	2.535	2.473	2.461	2.444
95 percent packout	2.412	2.354	2.342	2.326

---

[a] From Table 7.

[b] Based on price of $2 per bushel for green sweet potatoes packed in new baskets.

In making comparisons with prices of cured sweet potatoes, the reader should keep in mind that these unit cost estimates refer to all marketable potatoes, including No. 2's and jumbos as well as U.S. No. 1's.

With a 90 percent packout, average costs decline rather rapidly up to an annual output of about 40 thousand bushels but level off beyond this output. Average cost on a per-stored-bushel basis declines about 5 cents per bushel from 20 to 40 thousand bushel output but only declines by 1 cent between the other two levels of output. This is represented graphically in Figure 2 when average costs are measured in bushels marketed. Economies to size beyond a 40 thousand bushel storage house are small.

Regression Equations for Cost Estimation. An analysis of total costs of curing, storing, grading and packing sweet potatoes in four model houses has been presented. These estimates provide information regarding the relationship of volume and cost at selected levels of operation. These data can be used to develop a more general relationship between total season cost, packout level, and quantity of potatoes stored.

A least squares linear regression equation fitted to the estimates of total season cost at discrete volume and shrinkage levels is a good estimater of total season cost. The following equation expresses the linear relation between total season cost and volume of potatoes stored and packout assumes a \$2 per bushel raw potato price:

$$TSC = \$2152 + \$1.995V + \$.009385S + \$.0019997VS \qquad (1)$$

where

TSC = total season cost for \$2 green sweet potatoes

V = volume of green sweet potatoes stored in bushels

S = percent packout of marketable potatoes.

Estimated TSC of curing and storing potatoes are presented in Table 10. Quantities of potatoes stored correspond with capacity of the four model houses. A comparison with cost estimates presented in Table 7 shows differences of less than 300 dollars or less than 1/2 of 1 percent.

To estimate total season cost at raw product prices other than \$2 per bushel, Equation 1 is adjusted as follows:

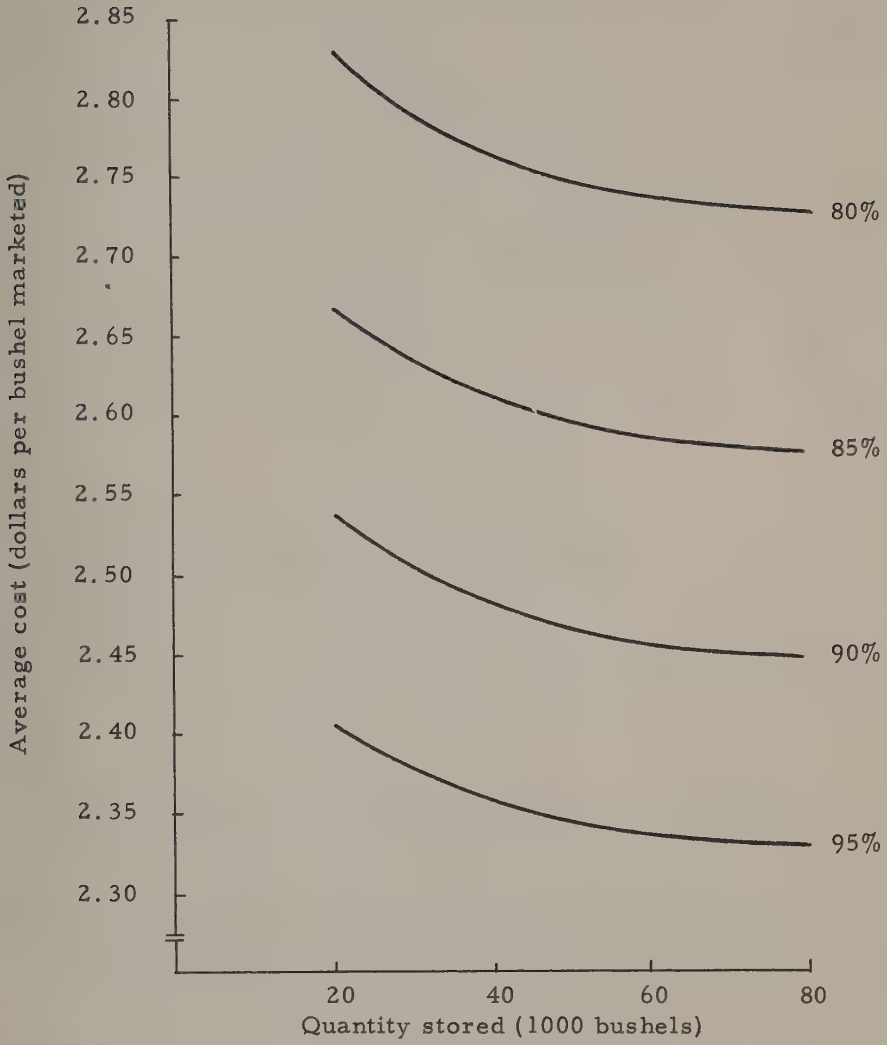


Figure 2. Estimated average cost associated with curing and storing operations at selected packout levels assuming capacity operations with a raw product price of $2.00 per bushel

Table 10. Estimated total season costs of curing, storing, grading and packing sweet potatoes assuming capacity operation and \$2 per bushel raw product price[a]

Quantity stored[b]	Percent packout			
	80	85	90	95
(1000 bushels)	(dollars per season)			
20	45,252	45,452	45,652	45,852
40	88,352	88,752	89,152	89,552
60	131,452	132,052	132,652	133,252
80	174,552	175,352	176,152	176,952

[a] Estimated using Equation 1.

[b] These storage levels correspond to capacity of the four model houses.

$$TSC^{*} = \$2,152 + \$1.995V + \$.009385S + \$.0019997VS - (\$2 - P_n)V \qquad (2)$$

where

TSC^{*} = total season cost for green sweet potatoes purchased at price P_n

P_n = green potato price per bushel

S = percent packout of marketable potatoes.

Estimated total costs at various raw sweet potato prices and a 90 percent packout are presented in Table 11. Total cost for other levels of packout can be readily computed.

Average season cost of marketable potatoes may be derived by dividing total season cost by volume of marketable potatoes if percent packout of marketable potatoes is fixed at a specified level. The estimating equation for average total cost per bushel is as follows:

$$ASC = \frac{\$2,152 + \$1.995V + \$.009385S + \$.0019997VS}{Q} \qquad (3)$$

where ASC = average cost per bushel of cured potatoes

V = volume of green sweet potatoes stored in bushels

S = fixed packout level

Q = volume of cured sweet potatoes sold in bushels.

Table 11. Estimated total curing and storing costs at varying raw product prices and selected outputs assuming 90 percent packout and 100 percent capacity operation

Raw potato price[a]	Quantity stored in 1000 bushels			
	20	40	60	80
(dol. /bu.)	(dollars per season)			
1.60	37,652	73,152	108,652	144,152
1.80	41,652	81,152	120,652	160,152
2.00[b]	45,652	89,152	132,652	176,152
2.20	49,652	97,152	144,652	192,152
2.40	53,652	105,152	156,652	208,152

[a] Prices represent the assumed price of green sweet potatoes delivered to the curing and storing house.

[b] Base price for raw sweet potatoes which was used to estimate Equation 1.

ESTIMATED REVENUES

Wholesale Prices. New York City is one of the major markets for North Carolina sweet potatoes. Wholesale prices for October, November, and December, months in which a very large portion of the marketable crop is sold, did not vary as much from year to year as did prices in the other eight months during the ten-year period, 1953 to 1963. October wholesale prices varied from a low of $3.12 per bushel in 1959 to a high of $4.35 per bushel in 1961 and averaged $3.56 per bushel (Table 12).

Comparisons with prices during the following January-April period are possible for nine seasons. The high price during these four months averaged $4.75 per bushel, $1.19 above the October average. In one year the price rise was less than $.50, in two years between $.50 and $.99, in four years between $1.00 and $1.49, in one year between $1.50 and $1.99 and in the high year $2.29.

Comparisons between New York City prices and auction prices for green sweet potatoes at Bethel, North Carolina, in October are possible for several years during this period. While not directly comparable, they give some indication of the early season spread between prices in the two locations.

Table 12. Wholesale prices at New York City for North Carolina Porto Rico type sweet potatoes by month, 1953-1962

Month	Year									
	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
	(dol. /bu.)									
January	6.08	3.86	4.87	3.86	4.32	4.60	4.75	3.45	4.71	4.95
February	6.09	3.90	4.96	3.68	4.27	5.12	4.42	3.31	5.14	5.00
March	6.20	4.00	5.00	3.57	4.22	5.60	4.32	3.38	5.06	5.15
April	6.92	4.70	4.79	3.26	4.75	5.54	4.10	3.42	5.38	5.30
May	6.49	5.02	4.69	3.29	5.36	5.67	4.25	3.84	5.75	5.51
June	5.77	5.82	4.78	3.45	5.94	5.49	3.92	4.62	6.14	5.31
July	--	7.00	4.62	--	6.38	5.63	3.86	5.75	7.56	4.95
August	--	7.00	4.12	--	--	--	4.18	4.83	5.67	4.19
September	--	--	3.41	--	3.62	3.19	3.22	3.78	4.00	3.76
October	3.40	3.96	3.26	3.49	3.31	3.62	3.12	3.50	4.35	3.54
November	3.50	4.02	3.73	3.74	3.65	4.44	3.26	4.00	4.80	3.52
December	3.91	4.74	3.98	4.12	4.30	4.92	3.38	4.65	4.88	3.45

Source: Fresh Fruit and Vegetable Prices, annual reports; USDA, Agricultural Marketing Service, Fruit and Vegetable Division, Washington.

October average	Bethel, N. C.	New York City
	(dol. /bu.)	
1957	2.04	3.31
1958	2.74	3.62
1959	1.96	3.12
1960	2.57	3.50

Total revenues from curing, storing, grading and packing operations were estimated for varying levels of output. Five different prices of cured potatoes were used because of wide fluctuations in prices at major markets. Estimates of total revenues for a 90 percent packout and varying outputs are presented in Table 13. At the $2 per bushel cured price, total revenue increases from $36,000 per year for a firm storing 20,000 bushels to $144,000 per year for a firm storing 80,000 bushels. The level of packout has a proportional effect on total revenue.

Table 13. Estimated total revenues from curing and storing operations at varying cured potato prices assuming four quantities stored, 90 percent packout and 100 percent capacity operations

Price of cured potatoes[a]	Quantity of cured potatoes marketed in 1000 bushels[b]			
	18	36	54	72
(dol. /bu.)	(1000 dol. /season)			
2.00	36,000	72,000	108,000	144,000
2.50	45,000	90,000	135,000	180,000
3.00	54,000	108,000	162,000	216,000
3.50	63,000	126,000	189,000	252,000
4.00	72,000	144,000	216,000	288,000

[a] Prices represent the price of cured potatoes at the curing and storing house.

[b] Bushels marketed correspond to capacity operation of the four model houses.

Net Revenues. Net revenues were estimated by subtracting total season costs, at four levels of packout and varying prices of green and cured sweet potatoes, from total revenues at varying cured potato prices. Estimated net revenues assuming a 90 percent packout are presented in Table 14. Information for 80, 85 and 95 percent packouts is presented in Appendix Tables 1, 2, and 3, respectively.

At 90 percent packout, net revenues are negative at all output levels and prices of green potatoes when the price of cured potatoes is $2 per bushel. At a cured potato price of $3 or more, net revenues are positive at all prices of green potatoes considered. For a given quantity stored, net revenue increases when price of cured potatoes is increased relative to the price of green potatoes and decreases when price of green potatoes is increased relative to the price of cured potatoes.

EFFECTS OF LESS THAN CAPACITY OPERATIONS

Total Costs. Up to this point, rate of operation has been assumed to be 100 percent. Effects of operating at less than 100 percent are presented in Table 15. At 50 percent capacity, only 10,000 bushels

Table 14. Estimated net returns from curing and storing operations assuming four quantities stored, varying raw and cured potato prices, capacity operations and 90 percent packout

Quantity stored and price of raw potatoes	Price of cured potatoes in dollars per bushel				
	2.00	2.50	3.00	3.50	4.00
			(dol. /season)		
20,000 bushels (dol. /bu.)					
1.60	-1,652	7,348	16,348	25,348	34,348
1.80	-5,652	3,348	12,348	21,348	30,348
2.00	-9,626	-626	8,348	17,348	26,348
2.20	-13,652	-4,652	4,348	13,348	22,348
2.40	-17,652	-8,652	348	9,348	18,348
40,000 bushels (dol. /bu.)					
1.60	-1,152	16,848	34,848	52,848	70,848
1.80	-9,152	8,848	26,848	44,848	62,848
2.00	-17,152	848	18,848	36,848	54,848
2.20	-25,152	-7,152	10,848	28,848	46,848
2.40	-33,152	-15,152	2,848	20,848	38,848
60,000 bushels (dol. /bu.)					
1.60	-652	26,348	53,348	80,348	107,348
1.80	-12,652	14,348	41,348	68,348	95,348
2.00	-24,652	2,348	29,348	56,348	83,348
2.20	-36,652	-9,652	17,348	44,348	71,348
2.40	-48,652	-21,652	5,348	32,348	59,348
80,000 bushels (dol. /bu.)					
1.60	-152	35,848	71,848	107,848	143,848
1.80	-16,152	19,848	55,848	91,848	127,848
2.00	-32,152	3,848	39,848	75,848	111,848
2.20	-48,152	-12,152	23,848	59,848	95,848
2.40	-64,152	-28,152	7,848	43,848	79,848

Table 15. Estimated total costs of operating four selected sizes of curing houses at varying rates of capacity assuming a 90 percent packout and $2 per bushel raw potato price

Quantity stored	Percent of capacity		
	100[a]	75[b]	50[b]
(1000 bushels)		(dol. /season)	
20	45,652	34,708	23,763
40	89,152	67,550	45,965
60	132,652	100,391	68,135
80	176,152	133,276	90,400

[a] Based on Equation 1.

[b] Assumes that average variable costs are the same as for 100 percent capacity.

are cured in a 20,000 bushel house. Average variable costs are not affected since it is assumed that rate of output remains constant but the crew works a smaller number of hours. At 50 percent capacity, estimated total cost drops 48 percent in a 20,000 bushel house and 49 percent in the 80,000 bushel house. The reason for this is that fixed costs make up a very small part of total costs. Average variable costs were calculated by subtracting estimated total fixed costs (Table 4) from estimated total cost for each size house and dividing the quantity stored at 100 percent capacity.

Net Revenue. Effects of less-than-capacity operations on net revenue are illustrated in Table 16. All three levels allow for losses in storage and grading. A 90 percent packout was selected to make comparisons of varying rated capacity operations.

For a $2 per bushel cured potato price assuming a $2 green potato price, net revenues are negative at all four levels of output and three rates of operation. However, losses in net revenue are reduced by lowering the rate of operation from 100 to 50 percent rated capacity. At other price levels, net revenue was increased as volume placed in storage increased.

SUMMARY

Several factors which influence the profitability of sweet potato curing, storing, grading and packing were considered in this study. These variables were quantity of potatoes stored, price of green and cured potatoes, rate of capacity operation and percent packout. The four model plants on which the analysis is based had storage capacity of 20, 40, 60 and 80 thousand bushels per year.

Table 16. Net returns from curing, storing, grading and packing operations at varying rates of capacity and cured potato prices, assuming a 90 percent packout and a $2 per bushel green sweet potato price

Price of cured potatoes and percent of capacity	Capacity of house in thousands of bushels			
	20	40	60	80
	(dol. /season)			
$2/bushel (percent of capacity)				
100	-9,652	-17,152	-24,652	-32,152
75	-7,708	-13,550	-19,391	-25,276
50	-5,763	-9,965	-14,135	-18,400
$2.50/bushel (percent of capacity)				
100	652	848	2,348	3,848
75	-958	-50	859	1,724
50	-1,263	-965	-635	-400
$3/bushel (percent of capacity)				
100	8,348	18,848	29,348	39,848
75	5,792	13,450	21,109	28,724
50	3,237	8,035	12,865	17,600
$3.50/bushel (percent of capacity)				
100	17,348	36,848	56,348	75,848
75	12,542	26,950	41,359	55,724
50	7,737	17,035	26,365	35,600
$4/bushel (percent of capacity)				
100	26,348	54,848	83,348	111,848
75	19,292	40,450	61,609	82,724
50	12,237	26,035	39,865	53,600

It was found that average cost decreased by about seven cents per bushel as plant capacity increased from 20 to 40 thousand bushels and by 10 cents per bushel as the quantity stored increased to 80 thousand bushels.

The profitability of curing and storing sweet potatoes depends very heavily on the relative price of green and cured potatoes. For costs to be recovered, the price of cured potatoes must be from 33 to 83 cents greater than the price of green potatoes depending on the level of packout, size of operation and percent of operating capacity. The necessary price difference declined as size of operation and percent packout increased.

Percent packout affected costs by as much as $.42 per bushel. For example, average cost was $2.83 per bushel marketed with 80 percent packout but only $2.41 per bushel marketed with 95 percent packout, assuming 20,000 bushels stored per year and $2 per bushel paid for green potatoes. Effects on costs of changing packout levels were not appreciably altered by changing size of house provided capacity operation was assumed.

Percent of rated operating capacity had an important effect on returns. For example, net returns were reduced from $8,348 to $5,792 per season if percent of rated capacity were reduced from 100 percent to 75 percent and further reduced to $3,237 per season if percent of rated capacity were reduced to 50 percent, assuming a 90 percent packout, 20,000 bushels stored, $2 green potato price and $3 per bushel cured potato price. This study points out the importance of an adequate raw product supply in order that near capacity operations can be maintained.

LIST OF REFERENCES

Lutz, J. M. and J. W. Simons. 1958. Storage of sweet potatoes. U. S. Department of Agriculture, Bulletin Number 1442, U. S. Government Printing Office, Washington, D. C.

Mathia, G. A. 1962. Selection of the optimum number, size and location of processing plants: An application to the sweet potato industry of eastern North Carolina. Unpublished Ph. D. thesis, North Carolina State College, Raleigh (University microfilms, Ann Arbor).

Mathia, G. A. and R. A. King. 1962a. Planning data for the North Carolina sweet potato industry: 1. Prices, production and assembly costs. A. E. Information Series Number 92, North Carolina State College, Raleigh, North Carolina.

Mathia, G. A. and R. A. King. 1962b. Planning data for the sweet potato industry: 3. Selection of the optimum number, size and location of processing plants in eastern North Carolina. A. E. Information Series Number 97, North Carolina State College, Raleigh, North Carolina.

Williams, F. W. and M. B. Allen. 1960. The southeastern vegetable processing industry, 1960. U. S. Department of Agriculture Marketing Research Report Number 527, U. S. Government Printing Office, Washington, D. C.

Appendix Table 1. Estimated net returns from curing and storing operations, assuming four quantities stored, varying raw and cured potato prices, capacity operations and 80 percent packout

Quantity stored and price of raw potatoes	Price of cured potatoes (dol. per bushel)				
	2.00	2.50	3.00	3.50	4.00
			(dol. per season)		
20,000 bushels					
(dol. per bu.)					
1.60	-5,252	2,748	10,748	19,748	26,748
1.80	-9,252	-1,252	6,748	15,748	22,748
2.00	-13,252	-5,226	2,748	11,748	18,748
2.20	-17,252	-9,252	-1,252	7,748	14,748
2.40	-19,252	-11,252	-3,252	5,748	12,748
40,000 bushels					
(dol. per bu.)					
1.60	-8,352	7,648	23,648	39,648	55,648
1.80	-16,352	-352	15,648	31,648	47,648
2.00	-24,352	-8,352	7,648	23,648	39,648
2.20	-32,352	-16,352	-352	15,648	31,648
2.40	-40,352	-24,352	-8,352	7,648	23,648
60,000 bushels					
(dol. per bu.)					
1.60	-11,452	12,548	36,548	60,548	84,548
1.80	-23,452	548	24,548	48,548	72,548
2.00	-35,452	-11,452	12,548	36,548	60,548
2.20	-47,452	-23,452	548	24,548	48,548
2.40	-59,452	-35,452	-11,452	12,548	36,548
80,000 bushels					
(dol. per bu.)					
1.60	-14,552	17,448	49,448	81,448	113,448
1.80	-30,552	1,448	33,448	65,448	97,448
2.00	-46,552	-14,552	17,448	49,448	81,448
2.20	-62,552	-30,552	1,448	33,448	65,448
2.40	-78,552	-46,552	-14,552	17,448	49,448

Appendix Table 2. Estimated net returns from curing and storing operations, assuming four quantities stored, varying raw and cured potato prices, capacity operations and 85 percent packout

Quantity stored and price of raw potatoes	Price of cured potatoes (dol. per bushel)				
	2.00	2.50	3.00	3.50	4.00
	(dol. per season)				
20,000 bushels					
(dol. per bu.)					
1.60	-3,452	5,048	13,548	22,048	30,548
1.80	-7,452	1,048	9,548	18,048	26,548
2.00	-11,452	-2,952	5,548	14,048	22,548
2.20	-15,452	-6,952	1,548	10,048	18,548
2.40	-17,452	-8,952	-452	8,048	16,548
40,000 bushels					
(dol. per bu.)					
1.60	-4,752	12,248	29,248	46,248	63,248
1.80	-12,752	4,248	21,248	38,248	55,248
2.00	-20,752	-3,752	13,248	30,248	47,248
2.20	-28,752	-11,752	5,248	22,248	39,248
2.40	-36,752	-19,752	-2,752	14,248	31,248
60,000 bushels					
(dol. per bu.)					
1.60	-6,052	19,448	44,948	67,448	95,948
1.80	-18,052	7,448	32,948	55,448	83,948
2.00	-30,052	-4,552	20,948	43,448	71,948
2.20	-42,052	-16,552	8,948	31,448	59,948
2.40	-54,052	-28,552	-3,052	19,448	47,948
80,000 bushels					
(dol. per bu.)					
1.60	-7,352	26,648	60,648	94,648	128,648
1.80	-23,352	10,648	44,648	78,648	112,648
2.00	-39,352	-5,352	28,648	62,648	96,648
2.20	-55,352	-21,352	12,648	46,648	80,648
2.40	-71,352	-37,352	-3,352	30,648	64,648

Appendix Table 3. Estimated net returns from curing and storing operations, assuming four quantities stored, varying raw and cured potato prices, capacity operations and 95 percent packout

Quantity stored and price of raw potatoes	Price of cured potatoes (dol. per bushel)				
	2.00	2.50	3.00	3.50	4.00
			(dol. per season)		
20,000 bushels					
(dol. per bu.)					
1.60	148	9,648	19,148	28,648	38,148
1.80	-3,852	5,648	15,148	24,648	34,148
2.00	-7,852	1,648	11,148	20,648	30,148
2.20	-11,852	-2,352	7,148	16,648	26,148
2.40	-13,852	-4,352	5,148	14,648	24,148
40,000 bushels					
(dol. per bu.)					
1.60	-2,448	21,448	40,448	59,448	78,448
1.80	-5,552	13,448	32,448	51,448	70,448
2.00	-13,552	5,448	24,448	43,448	62,448
2.20	-21,552	-2,552	16,448	35,448	54,448
2.40	-29,552	-10,552	8,448	27,448	46,448
60,000 bushels					
(dol. per bu.)					
1.60	4,748	33,348	61,748	90,248	78,748
1.80	-7,252	21,248	49,748	78,248	66,748
2.00	-19,252	9,248	37,748	66,248	54,748
2.20	-31,252	-2,752	25,748	54,248	42,748
2.40	-43,252	-14,752	13,748	42,248	30,748
80,000 bushels					
(dol. per bu.)					
1.60	7,048	45,048	83,048	121,048	159,048
1.80	-8,952	29,048	67,048	105,048	143,048
2.00	-24,952	13,048	51,048	89,048	127,048
2.20	-40,952	-2,952	35,048	73,048	111,048
2.40	-56,952	-18,952	19,048	57,048	95,048

Agricultural Experiment Station

North Carolina State College

Raleigh, N. C.

R. L. Lovvorn, Director of Research

Bulletins of this station will be sent free to all citizens who request them.

274 R2 P2472
05/26/04 33357 SELB

Duke University Libraries
D02982556.